ENGINEERING

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Weaving extra wide asbestos cloth. On the right is the roll of woven cloth before removal from the loom for inspection and finishing. *(Nurnberg photograph)*

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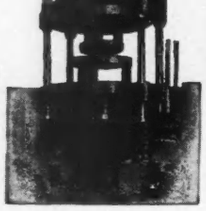

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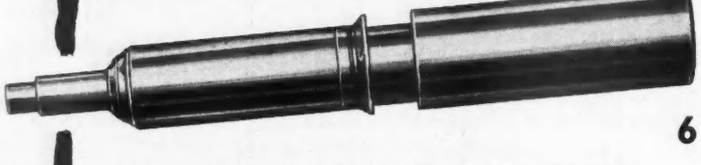

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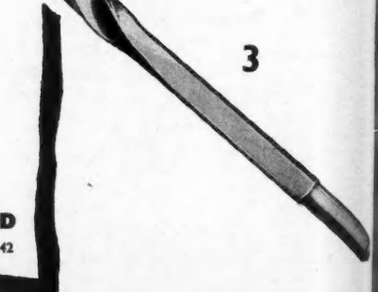

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ENGINEERING Impact

of Cutting Grants to Universities

IF THE master of a ship heading for the rocks switched the engines off, instead of using them to make for the open sea, it is likely that his conduct, if he survived, would later come up for censure. It is hard to resist the impression that hobbling the industrial advance by which manufacturing Britain can flourish is precisely what is now going on.

The suspension of five new grants to universities, three for nuclear reactors and two for radio telescopes, that were to have been included in the estimates of the Department of Scientific and Industrial Research for 1962-63, may have a number of possible effects. One absolutely certain result will be the encouragement of the belief that those who want to make a career starting from this kind of training had better look round the United States and the Continent to find the facilities they need.

The position may be reviewed again in November, but at the least the step is another serious delay piled on top of the existing two or three year hold-up. The nuclear reactors were for the Scottish Universities, Liverpool and Manchester Universities and for London University. From Queen Mary College, London, the decision has been described as a severe blow and there is a danger of staff laboriously assembled now dispersing, since they cannot get on with their work without the equipment.

Most insidious of all is the acceptance of this lethargic approach brought about by those in charge of programmes being certain of nothing but delays. It cannot make for the kind of technical advance and high-level training which have contributed to the expansion of industry.

The early hopes associated with nuclear power are now chiefly memories but there is no doubt that the long-term importance of nuclear engineering is as great as ever. Shutting ourselves out from the future in such a key field as this is demoralising for the present, the reverse of helpful for the future, and a sure way to turn the thoughts of some of the best engineers and scientists towards flight to lands of more prudent administration.

Good ECGD Business in Second Quarter

A RECORD level of business under Export Credits Guarantee Department "commercial" insurances in the second quarter of the year has been declared. The total under this heading reached £189·2 million, the highest level yet recorded in the second quarter, though not quite up to the previous highest for any quarter—the first three months of this year, when the total business under commercial insurances was £194·8 million. The figure for the second quarter of 1961 was 17 per cent up on the equivalent period in 1960.

At the end of the quarter there were 5,537 short term policies current, for a total of £777·2 million. A year ago the number of policies current had been 4,996 valued at £673·6 million. Among the many significant export orders covered by the ECGD's policies are one of £1·3 million a year for telecommunication equipment and one of £1·0 million a year for general engineering merchants.

There was a sharp fall in the medium term policies—to £13·1 million—compared with the previous quarter's £29·6 million. Among these were policies for fertilizer plant valued at £2·8 million, aircraft at £1·8 million, plant for car assembly and manufacture £1·4 million, and for chemical plants £4·6 million, of which £2·9 million was in connection with two plants in Russia.

The nature and extent of the policies of the Export Credit Guarantee Department indicate the widespread contribution of the Department to the export efforts of a diverse range of manufacturing concerns. The modifications in the Department's brief announced earlier in the year constitute a valuable aid to firms endeavouring to keep their profitability up by successful exporting at a time of increasingly difficult home market conditions.

No Order on Nuts and Bolts

AN IMPORTANT decision of the Restrictive Practices Court has been made in relation to members of the Black Bolts and Nuts Association of Great Britain.

The Court decided to make no order on an application for a declaration concerning a price agreement covering the Association's members. This agreement had been asserted by the Registrar of Restrictive Trading Agreements to be of like effect to an earlier agreement which the Court had on 15 July, 1960, decided to be contrary to the public interest—in some, though not all, of its terms.

Mr. Justice Diplock said, giving judgment, that in the original restrictions a distinction had been drawn between the supplies of goods to Government departments, railways and other large users on one hand, and other kinds of supplies in the alternative. Members of the Association could only sell ordinary supplies at fixed prices contained in, or able to be learned from, the price list of the Association.

Large user prices were not fixed, but there was an arrangement which stopped a Dutch auction among members making tenders for large user supplies. The original restrictions in connection with ordinary supplies, excluding a restriction relating to quantity discounts, had been declared by the Court to be not contrary to the public interest. All the original restrictions relating to the large user supplies were found to be contrary to the public interest.

This finding of the Court meant that the original agreement became void for those restrictions relating to large user supplies, and all the members were free to deal with large user supplies on whatever terms they thought fit. The dividing line in the original agreement had been between supplies of goods for Government departments, railways and other large users, and other, smaller, supplies.

Mr. Justice Diplock, continuing his judgment, said that the members had agreed, by a new agreement taking effect from 31 July, 1961, to submit large user supplies to restrictions identical with those that applied to ordinary supplies. These new restrictions were in general the same as those which the Court had declared to be not contrary to the public interest when applied to ordinary supplies; but with an alteration designed to allow the Association's members to supply goods at a price lower than the fixed price to an amount commensurate with any special saving in cost of production which resulted from any special nature or circumstances of the order.

No order was made as to an application.

of Instituting Work Study

OF ALL the contemporary "-isms" in engineering, work study is one of the few that have continued to grow in usefulness and in the respect they evoke among both advanced scientific management enthusiasts and solid, feet-on-the-ground managers.

The Institute of Work Study was formed last year. It grew out of the earlier Motion Study Society of Great Britain, the Work Study Society, the Institute of Economic Engineering and Society of Industrial Engineers. Its first President is Mr. R. M. Currie, C.B.E., and none deserves the honour more, as his fame in the field of work study is world-wide. He founded the Work Study Department of ICI in 1947. His staff then consisted of 30 men; today ICI have 1,800 full-time specialists in work study. They have run 1,900 training and appreciation courses, and by Mr. Currie's efforts, work study techniques have been introduced in many industrial concerns and into the armed forces, hospitals, and even agriculture. He has travelled extensively on technical missions, and a number of countries abroad have had the benefit of his advice. A few weeks ago he was also elected the first President of the newly-formed European Work Study Federation.

The Royal Navy have applied work study with considerable benefits, and when Mr. Currie was recently invested with the badge of office of the President of the Institute of Work Study, it was Admiral of the Fleet the Earl Mountbatten of Burma who came to the Livery Hall of the Guildhall in London to invest him and pay him a tribute.

With the full establishment of the Institute, and the growth in the number of people engaged in work study, further increases in productivity over a wider range of industries should now be possible.

Helicopter Noise and its Abatement

REGULAR services between London and the near continental cities with helicopters carrying 25 passengers or more will begin by 1965 or soon after. Fares will be comparable to those for first-class fixed-wing services. And services to provincial cities in the United Kingdom will follow if fares can be reduced to compete with those of other forms of transport.

These are three of the conclusions reached by a committee in a report just published by the Ministry of Aviation: *Report of the Committee on the Planning of Helicopter Stations in the London Area* (HM Stationery Office, 7s).

The committee found it very difficult to pinpoint a good site in central London. They estimated that helicopter services could only be economic if the heliport were sited within 15 minutes travelling time—say 2½ miles—of the main source and destination of the bulk of the passengers. Easy approaches by air at gradients not much steeper than 1 in 4 were deemed essential if operations were to continue in all weathers and, for the future, this could mean restrictions on building heights in the neighbourhood of the site.

The problem of noise was carefully considered by the committee and note made of the comprehensive research programme at Government establishments, by manufacturers and at the universities. By carefully choosing the site with regard to existing occupants of adjacent properties, by aligning take-off and landing paths over areas of poor utilization, and by limiting the frequency of flights, the committee thought a serious noise problem could be avoided —by day. But whether this would be true with high density traffic or at night they did not know. By 1975 the committee thought there would be 20 to 25 helicopter movements an hour from London's heliport, with 1½ million passenger movements a year.

It may be economically possible to limit building heights, but it certainly isn't good policy to sterilize even a small area. Noise annoyance is the critical factor and research into noise abatement at source is being actively pursued.

The committee conclude that "proposals for heliport development must be put in hand on the basis that noise can and will be brought down to reasonable levels."

and a Paper Survey in the Printing Industry

A MARKET research survey of considerable importance to the whole of Britain's printing industry is to be sponsored by the National Research Development Corporation. The survey, into paper-handling processes in the printing industry, will range widely over the subject from case and magazine binding to cutting and perforating.

At a time when all printed media of communication must look closely at their costs the NRDC survey, which is expected to report early next year, has two main benefits to give the industry.

The first will be realized if the report, as is expected, is able to put forward recommendations for the development and production of new equipment and processes. The second lies in the attention that the action of taking the survey will draw to the subject and the spreading of information on the most effective methods.

Carrying out the survey will be Mr. George Card, who is technical officer of Associated Iliffe Press. Over the next few months Mr. Card will be seeing a representative group of printers and binders, discussing with them their problems and particular needs. The anonymity of firms and individuals will be preserved and, as a further safeguard, those giving information will be able to request that particular items shall be excluded from the published report.

The Bailey Bridge

Equipment designed for war, but with peaceful uses. Such success due to two conditions: function is both military and civilian, and the design is for a range of almost unpredictable conditions.

THE BAILEY BRIDGE represents both the sword and the ploughshare. It makes no secret of the fact that its success and popularity arose in the first instance from a military necessity.

It arrived on the scene just in time to serve the Allied forces when they took the offensive during the latter part of the Second World War. In a civilian role its peacetime potential for emergencies and for temporary use by contractors on large construction sites has not yet been fully exploited; and the new uses constantly being devised for it are not always associated with pure bridging.

Rarely, even in Product Profile, is ENGINEERING able to review a piece of equipment which fulfilled so precisely the peculiar requirements for which it was designed—and then blossomed into a structure with such a multitudinous variety of uses. It shows that the supposed gulf between civil and military engineering problems, particularly those of the non-offensive kind, is virtually non-existent. But the Bailey bridge's long and distinguished career, not yet within sight of its end, teaches many more subtle lessons as this article will endeavour to show.

Its original conception was as a temporary bridge—one that would be capable of carrying the heaviest military load then envisaged, the Churchill tank, over any kind of gap an advancing army might suddenly encounter. Such a bridge would have to be economical in transport and be capable of rapid and foolproof erection without mechanical aids, by a gang of men working from one side of the gap.

The individual responsible for the idea about 1938, and for its later translation into reality, was Donald Bailey, B.Eng., A.M.I.C.E., M.I.Struct.E., later knighted for his inspiration. He is a civilian who was then holding a senior post at the Experimental Bridging Establishment of the War Office at Christchurch, Hants. Today he is the Director of MEXE (Military Equipment Experimental Establishment), as it is now known. Various kinds of temporary military bridges existed prior to the war, and those of the "through" type, in which the greatest possibilities seemed to lie, were all constructed on the "Meccano" principle; each member was a separate item, attached to its neighbour at the site.

Sir Donald realized that if groups of members could be permanently united to form prefabricated sections, keeping the maximum weight within the lifting capacity of six men, then a substantial increase in expediency of both transport and erection could be obtained. The feasibility of the proposed structure was therefore dependent upon the design of the principal load-carrying members, the side girders. If they could be shop assembled into light enough sections, and yet be of sufficient strength and simple to couple together, half the battle would be won.

The side panel was accordingly designed from

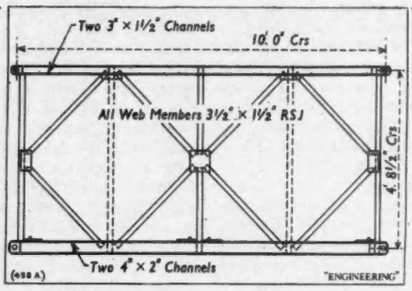
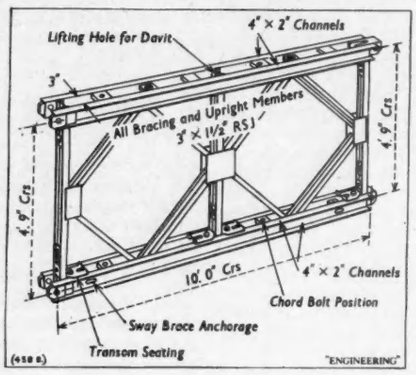


Fig. 1 (above) Early experimental Bailey panel.

Fig. 2 (below) Panel design adopted as standard.



first principles, exploiting to the full the advantage of the reduced number of site-made joints. Two important decisions were made:

(1) To use welding exclusively for uniting the component members of the panel.

(2) To employ high tensile steel (to BS 968, modified so as to be suitable for welding).

The basic panel design has changed little from the early experimental days. The first examples tested were of the form illustrated in Fig. 1, some having the vertical members shown dotted and others not. It was found that the structure behaved better without the extra verticals, and in the final design the channels in the top and bottom chords were made the same size and the panels became symmetrical, as shown in Fig. 2.

High tensile steel pins passing through mating jaws at the top and bottom chord ends permit the panels to be connected together end-to-end to form side trusses of varying length in 10 ft bays. The strength of the bridge can be tailored by arranging the trusses either singly or in groups of two or three side by side, at each side of the roadway. Additionally, they can be varied in depth by arranging the panels in double or triple storey construction.

From the panels, design of the cross girders or transoms, bracing, flooring, launching rollers and bearing equipment followed in natural sequence. The transoms rest upon the panel lower chords, and being retained by dowels need only a simple clamp to form a connection. The longitudinal floor supports were united in groups by welding and called "stringers"; they rest directly on top of the transoms which carry pairs of lugs on the top flange to retain them. Fig. 5, which with Fig. 1 is based on drawings published in the *Proceedings* of the Institution of Civil Engineers, illustrates the construction.

LAUNCHING PROCEDURE

Development of a launching procedure for the Bailey bridge, so vital to its success, progressed as part and parcel of the design, and is illustrated in Fig. 3. The use of a launching nose, light in weight relative to the bridge structure proper, was not new, though possibly employing standard bridge components was. The nose comprises panels and transoms in "single-single" construction with sway bracing and rakers but no flooring. The number of bays tilted up at the landing end was specified as a function of the span, and is effected by means of a short launching link fitted between the appropriate panel lower jaws.

In common with many a brilliant idea, the Bailey bridge was slightly ahead of its time in the sense that it was not until after the outbreak of hostilities that its full potential was suddenly recognized. Before it could be quantity produced detail drawings had to be made and rigid specifications drawn up in respect of each item. The work of a great number of manufacturers, large and small, eventually totalling about 600, had to be coordinated so that quantities of each part were produced in the right proportion.

More important, the standard of manufacture had to be rigidly controlled in the interests of safety and interchangeability. Panels were the crucial items and for a time every one was proof loaded in a special testing rig. The system of testing was to make the panels up into a girder and apply a predetermined overload in bending and shear. During the war the total number of panels made in the UK alone amounted to nearly 700,000, of which over 70 per cent were tested. Total failures were as low as 0·1 per cent.

Modifications to Bailey were few and simple.

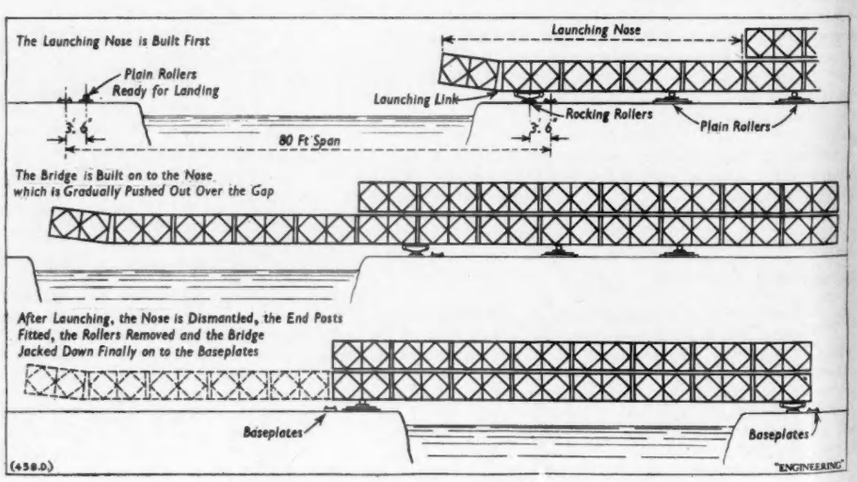


Fig. 3 Three stages in construction of a bridge with an 80 ft span.

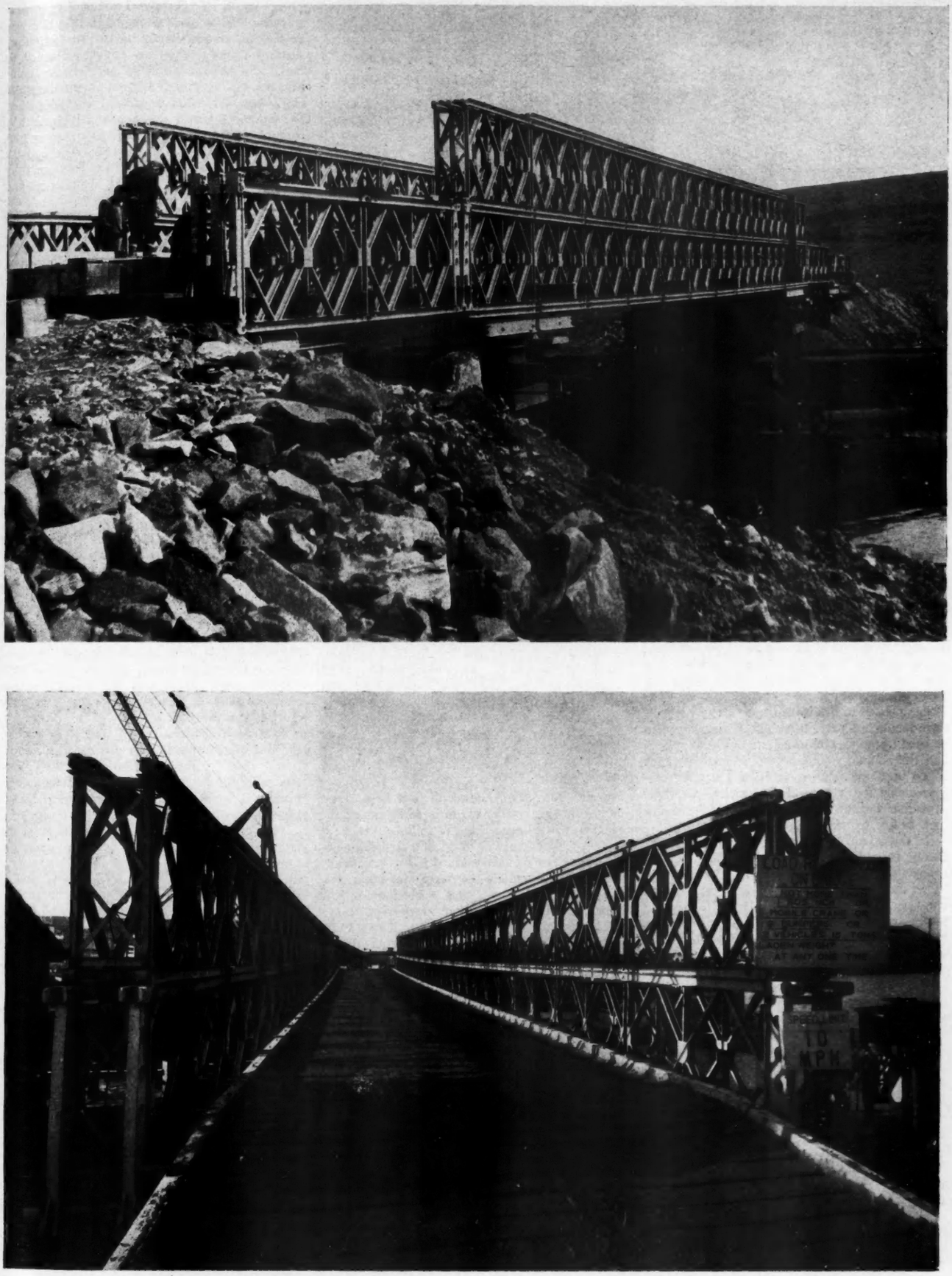


Fig. 4 Designed and built to satisfy instantly a temporary but essential need.

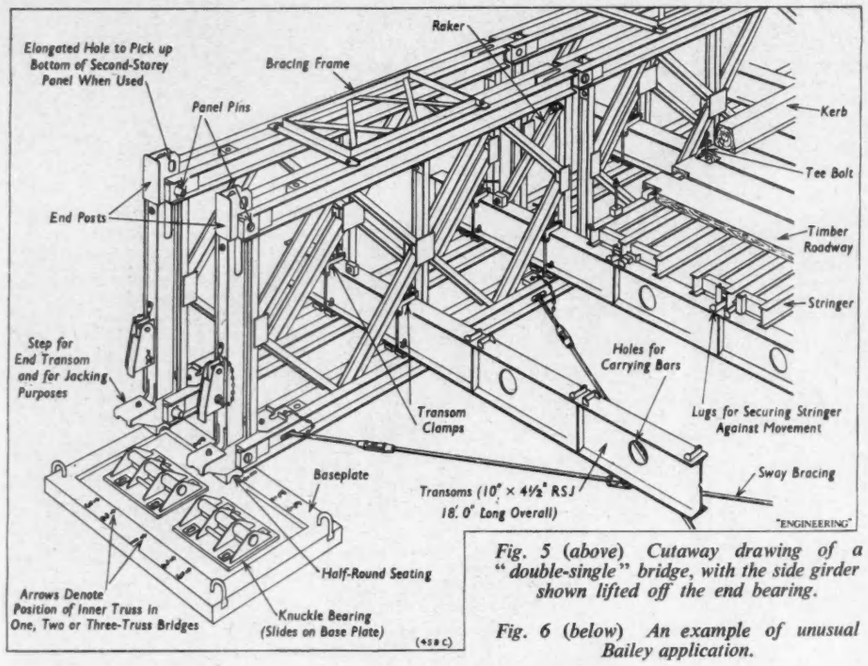
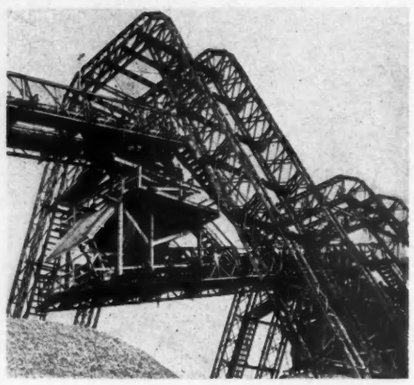


Fig. 5 (above) Cutaway drawing of a "double-single" bridge, with the side girder shown lifted off the end bearing.

Fig. 6 (below) An example of unusual Bailey application.



Early in its career the size of the welded gusset plates in the panel was increased. Later, as military loads were becoming bigger, the width of roadway was increased from 10 ft 9 in to 12 ft 6 in, chiefly by lengthening and "fish-bellying" the transoms, which then became an eight-man instead of a six-man load. Even "Standard Widened" Bailey, as it was called, was soon inadequate in certain instances and at the end of the war "Extra Wide" was devised, giving another 15 in by a similar artifice. The clear width between panels is always about 2 ft greater, allowing for the kerbs.

Significant extensions to Bailey usage were the introduction of parts to enable the structure to be used upright as intermediate bridge supports, and the adaption of pontoons to enable Bailey to be used for floating bridging. Chord reinforcement was a later introduction, a simple expedient for raising the moment of resistance of a bridge to bending.

So far as the British Army is concerned the Bailey bridge is now considered obsolescent, though many armies overseas still purchase it. Increasing use of mechanical aids in order to conserve manpower has led MEXE to develop heavier types of bridge whose main components are no longer expected to be manhandled, and which have better load carrying capabilities. The Bailey principle has not, however, been discarded; the Heavy Girder Bridge introduced about ten years ago has a marked resemblance to its lighter predecessor, even to the characteristic "twin lozenge" shape of the panels.

The success of Bailey can therefore be traced directly to its timeliness: it was needed by the British Army so long as the Army was sufficiently mechanized to need bridging at all, but ceased to be ideal when mechanization invaded bridge erection itself.

It is generally the civilian uses that make Bailey news today, and its rapidly increasing application in this sphere is partly due to availability as the War Office gradually sheds its stock. With the use of new or reconditioned Bailey for civilian purposes, two important factors must be taken into account.

The first is the loading stipulation. In military life Bailey bridging can generally expect to enjoy some degree of control over the loads passing over it. Maximum loads will only be allowed on the bridge one at a time; furthermore the exact weight of every kind of military vehicle is known. When sold or hired to a civil engineering contractor or local authority, it is practically impossible to regulate the passage of loads over the bridge in this way, and in civilian use it is customary to allow a greater factor of safety.

The second is the question of anticipated life. Fatigue failure of panels is a distinct possibility, particularly if the equipment has been subjected to repeated overloading over a lengthy period. Those places most subject to fatigue cracks are known and periodic examination should obviate any risk of actual failure.

PEACETIME POTENTIAL

Many thousands of sappers became familiar with Bailey during the war, and not a few must have been struck by the simple idea coupled with the sound engineering that it represents. One of the first companies to explore the possibilities of selling wartime Bailey bridging on the civilian market was Mabey and Johnson Limited. Their first sales were made in 1946, since when the business has steadily expanded. They stock reconditioned material for sale or hire. They have a design team, and an erection gang that have been known to erect and open a bridge within 48 hours of getting the inquiry.

The sole licensees for manufacturing Bailey components under the War Office patents are Thos. Storey (Engineers) Limited. This firm was one of the many engaged during the war in making certain Bailey parts. In 1949 they successfully negotiated an exclusive licence to make and sell the whole range of Bailey components, having already secured potential custom from some of the oil companies. By 1960, when the company joined the Acrow Group, it had expanded from small beginnings to an organization with about 400 employees. As they have direct liaison with the War Office, they are fully informed on current military experience and recommendations. In addition to being the sole licensees for manufacture, Thos. Storey (Engineers) also sell and hire out reconditioned components.

Bailey manufacture is not a matter to be taken lightly. New items are subject to War Office inspection to ensure that the original standards and interchangeability are maintained. Every new panel is tested on an approved testing rig. Thos. Storey (Engineers) have also produced two addendums to the original design, covered by their own patents. They are described below.

Steel decking is a popular alternative to the original timber flooring, in which the wear and tear of traffic continually passing soon gives rise to movement between the stringers and transoms creating rapid wear and a good deal of noise. It consists of fabricated box section units laid longitudinally on the transoms, and is particularly suitable for the more permanent installations where asphalt covering is provided. They also devised an expanding panel pin to minimize the characteristic "sag" of a Bailey bridge, engendered principally by the $\frac{1}{32}$ in fitting allowance, for special cases where the natural sag is considered undesirable.

Another development by the company, which started as an ancillary and which has since blossomed out into a product in its own right, is that of Uniflotes. They consist of steel pontoon units which can be linked together either as floating Bailey piers or to form ferry craft of variable size.

The growing popularity of Bailey for civilian use is dependent essentially on customer education. The two firms just mentioned will examine any proposal for applying Bailey and their engineers will work out a detailed scheme. What factors are likely to influence the customer?

First comes the question of cost related to the intended degree of permanence of the structure. Obviously for temporary site bridging, road diversion, gantries or derrick gabbards, Bailey should at once recommend itself. It is also often at an advantage as scaffolding for arch bridge repairs, or for carrying shuttering for a concrete bridge. It bypasses the drawing office to a great extent, and its ready transportability and re-use value are important assets.

Secondly comes the speed of delivery and erection. For emergency use, for example, when a bridge has been washed away, it is often the quickest solution. Though limitations on traffic loadings may have to be imposed, it is better than no bridge at all until more permanent remedial measures can be taken.

Thirdly the terrain. In underdeveloped countries where wheeled traffic is still in its infancy, a Bailey bridge is often adequate, perhaps for many years. Existence of a new bridge tends to engender more traffic and the Bailey can be strengthened periodically until, by the time a purpose-made structure becomes a necessity, it will have paid for itself many times over.

Thos. Storey (Engineers) Limited, 8 South Wharf, London W2 (Figs. 2 and 6).
Mabey and Johnson Limited, 54 Victoria Street, London SW1 (Fig. 4).

Plain Words

By Capricorn

ONE of the minor hazards of working in an office, whether in a city skyscraper or on a civil engineering site, is the pleasure or dismay which the day's post can bring. Will you receive a veiled threat of legal action, or perhaps a simple letter of grateful thanks? Imagine, then, my delight and admiration when I received this letter:

"Dear Sir,

I enclose a copy of a reprint of a paper I wrote in 1929 on the subject of "Rockets." It is a simple summary of the technique of rocket propulsion and there are some speculations on the possibility of space travel. Re-reading the paper in 1961, I thought I would have it reprinted and offer the copies for sale, the net proceeds to be given to the Henry Tizard Memorial Fund."

The letter ended with information on the arrangements for the sale of the reprint (this information is given in the New Books column on page 152 of this issue of ENGINEERING), and it was signed "Paul Adorian, F.C.G.I., M.I.E.E., M.Brit.I.R.E."

Part of his paper was devoted to a review of rocket development at that time, mainly in Germany. An Opel rocket-propelled motor car had reached a speed of 236 km an hour, and secret experiments were being started on rocket aeroplanes. There is a discussion of interplanetary flight, and of a German's invention of a rocket gun "to shoot London from Berlin, or if you prefer it, to shoot Berlin from London." Some of the pictures show "Rokar II"—a rocket-driven model car which ran along an aerial wire. It was built by Mr. Adorian and his colleague, Dr. H. Heywood.

No doubt there were quite a number of engineers and scientists who were working on rockets, or dreaming about them, at that time. Mr. Adorian makes no special claims, as his letter shows, but his paper is evidence of the importance of prediction and speculation in the development of engineering. Such willingness to stick your neck out, and to risk being proved wrong, is all too rare. We need more of it.

Two days after receiving Mr. Adorian's reprint, I was sent a Press release headed "Chris. J. Witting, Westinghouse Vice-President, 'Takes a Look' at Year 2000." Mr. Witting's vision ranges over a wide field. He foresees education in the home by dialling a telephone; houses which are "demountable," so that you take them with you when you move, or detach a room and give it to your son when he marries; a home health room which will record weight, temperature and blood pressure among other vital statistics"; and a host of other ideas which are exciting or appalling according to your point of view.

Please continue the good work, Mr. Witting. Develop these wonderful ideas and put them on the market. But don't let the prospect of them prevent me enjoying our primitive life in August, 1961.

Letters to the Editor

Evolving the Jaguar Engine

SIR, With reference to the article by Mr. Brian Lister entitled "Evolution of an Engine—the Jaguar XK" (ENGNG., 30 June '61, p. 887), I do wish people would get their facts right before bursting into print.

The original Jaguar SS car was fitted with an overhead valve combustion head which was designed and patented by myself. The first overhead valve cylinder head was fitted to a modified Standard side valve engine, and this was, in fact, the birth of the Jaguar car.

The first prototype engine fitted with this combustion chamber gave 102 hp. The 3½ litre version was then produced, using the same design of combustion chamber.

It was after the war that Sir William Lyons asked me what I thought was the next line of development, and I spent several weeks making many wooden models of various cylinder head designs, and airflowed the same, until I decided on the hemispherical type, in which I incorporated a curved valve port to impart turbulence, and this design was covered under British patent 591,157 in my name.

The four-cylinder experimental version which developed 146 hp was tuned by Weslake and Company Limited, and was subsequently fitted to Lieut.-Colonel Goldie Gardner's records car, and he captured several world's records using this engine. With regard to the racing type 35/40 cylinder head, this is based on British patent 28339/50, which again, is under my name.

With regard to these patents, Jaguar Cars Limited have the sole and exclusive use of them.

I met Mr. Brian Lister several years ago, and had a discussion about Jaguar engines when he was using Jaguar engines in his racing cars, and surely he must have realized that my work had played a pretty important part in the evolution of this engine.

Yours faithfully,
HENRY WESLAKE.

Weslake and Company Limited,
Rye Harbour, Sussex.
28 July, 1961.

Take a Tomato

SIR, A recent article in your journal gave us quite a chuckle in our office. I refer to your Automobile Review entitled "Take a Tomato when Touring Abroad" (ENGNG., 9 June '61, p. 799).

In the United States some of our more callous citizens refer to a girl as a "tomato." I am sure that the author of the article did not catch the pun, but as to his recommendation, many of us have seriously considered it.

Sincerely,
FRANK W. PARKER,
Design Division.

Boston Naval Shipyard,
Boston,
Massachusetts, USA.
20 July, 1961.

Electricity Links with Austria

SIR, May I comment upon the article entitled "The European Electric Power Situation" (ENGNG., 9 June '61, p. 791)?

Mr. J. H. M. Sykes states: "From Austria there are power transmission lines running both to Czechoslovakia and Hungary." This is not quite the case. While Austria has EHT connections with all other neighbours (the USSR, Western Germany, Switzerland, Italy and Yugoslavia), there exists at present no such line going to Hungary.

Incidentally, the EHT line to Czechoslovakia has a natural capacity (surge impedance load) of 260 MW and a thermal load limit of 520 MW; it is therefore a much stronger link than the new cable connecting Great Britain with France.

Yours faithfully,
VIKTOR GRABER.

Österreichische Elektrizitätswirtschafts-Aktiengesellschaft,
Vienna 1,
Austria.
18 July, 1961.

Events in Advance

Imperfections in Crystals

PLANS are now well in hand regarding the autumn conference of the X-Ray Analysis Group of the Institute of Physics and the Physical Society, which is to be held on 17 and 18 November next at the Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London SW1. The theme of the conference will be "Imperfections in Crystals."

Three sessions will be held, to be devoted, respectively, to the nature of crystal imperfections and of associated diffraction effects, to experimental methods for studying imperfections, and to the influence of imperfections on the physical properties of crystals. Among those who have been invited to address the conference are Dr. P. B. Hirsch, of the University of Cambridge, and Professor F. C. Frank, O.B.E., F.R.S., of the University of Bristol.

Correspondence in connection with the conference programme should be sent to the honorary conference secretary, Dr. G. S. Parry, Department of Chemical Engineering, Imperial College of Science and Technology, Prince Consort Road, London SW7.

Other inquiries should be addressed to the administration assistant, the Institute of Physics and the Physical Society, 47 Belgrave Square, London SW1. Telephone: BELgravia 6111.

Exhibitions and Conferences

Arranged in chronological order

Indian Industries Fair, Second.—Tues., 14 Nov., to Sun., 31 Dec., at the Exhibition Site, Mathura Road, New Delhi, India. Apply to the executive director, Indian Industries Fair, Federation of Indian Chambers of Commerce and Industry, Federation House, New Delhi 1. In the United Kingdom, inquiries should be addressed to the Export Publicity and Fairs Branch, Board of Trade, Horse Guards Avenue, London SW1. Tel. TRAfalgar 8855, ext. 2853. (*New information.*)

Engineering, Scientific and Technical Film Festival, Second International.—Thurs., 16 Nov., to Sat., 25 Nov., in Budapest, Hungary. This festival will coincide with a conference of the popular scientific section of the International Scientific Film Association. In the United Kingdom, further information may be obtained from Hungarian News and Information Service, 167 Kensington High Street, London W8 (Tel. WEStern 9561); and the Scientific Film Association, 3 Belgrave Square, London SW1. Tel. BELgravia 6188.

Design of Equipment for Human Use, Course on.—Mon., 20 Nov., to Fri., 1 Dec., at Engineers' House, Bristol 8. Organized by the Engineering and Allied Employers' West of England Association, Engineers' House, The Promenade, Clifton Down, Bristol 8. Tel. Bristol 3-9131.

Display Production and Screen Printing Exhibition and Product Fair.—Mon., 27 Nov., to Fri., 1 Dec., at Washington Hotel, Curzon Street, London W1. Organized by the Display Producers and Screen Printers Association, 28 Ely Place, Holborn Circus, London EC1. Tel. HOLborn 1746.

Programming of Research Reactors, Symposium.—In December, in Vienna. Apply to the International Atomic Energy Agency, Kaerntnerring, Vienna 1, Austria. (*This event may be brought forward to October.*)

Mechancial Handling Exhibition.—Tues., 8 May, to Fri., 18 May, 1962, at Earls Court, London SW5. Organized by the Iliffe journal *Mechanical Handling*, Dorset House, Stamford Street, London SE1. Tel. WATerloo 3333.

Using Glass Fibres to See Round Corners

Seeing round corners was only the first of many applications of fibre optics. Now the techniques can be used to obtain higher definition in photographs of moving subjects, or the picture can be scrambled for transmission in code.

FIBRE optics grew out of a need to look round corners—into complex castings or inside the kidney of a living person, for example. But it turns out that this is only one of a large number of ways that fibre optics devices can be used. They also make possible high-definition aerial reconnaissance, new ways of verifying signatures on cheques, ultra-fast camera lenses, new types of high-speed oscilloscopes. Their possible use in reading machines for computers and in spectrographic equipment, for astronomical telescopes is being considered. And other applications are known to be under development for military purposes.

The basic component in fibre optics is a cylindrical rod of glass. It may be as long as 25 ft and as narrow as 5 microns. Normally it is used in company with several thousand similar rods, all bundled together. Both flexible and rigid assemblies are used, and examples are shown in Figs. 1 and 2.

The basic idea behind fibre optics is that much of the light going into one end of a glass rod comes out of the other end. This is true even if the rod is bent or twisted. The effect is due to the fact that glass has a higher refractive index than air. Light rays can only get out of glass if they hit it at a big enough angle. Oblique rays just get reflected back. The situation is shown by the diagram in Fig. 3.

Fig. 1 Seeing clean round the bend: the flexible bundle of fibres transmits the image of the dime.

The fact that light can be piped round corners by using total internal reflection has been known for many years. The trouble was that it was not possible to pipe a clear image in this way, because in one rod the different parts of the image were reflected in different ways. The light coming out of the far end gave a good indication of the amount of light entering at the other, but the rays were jumbled up.

The idea that made it possible to pipe pictures around corners was that of using a large number of glass rods bundled together. To accommodate a large number of rods in a reasonable space they had to be reduced to minute diameters. When an image is focused on one end of such a fibre bundle, each fibre transmits the amount of light coming from the part of the image facing it. If the fibres are arranged in an identical manner at their far ends, an image emerges that represents the original one. It is built up of points of light of varying intensity—in much the same manner as half-tone illustrations in this journal are built up of dots of grey of varying intensity. The quality of the image transmitted by such a fibre bundle depends on the number of fibres that can be packed into the area of the image.

The same idea that makes it possible to pipe light pictures along twisted paths—the splitting up of the image along a large number of parallel paths—also gives rise to a number of unforeseen applications. For it becomes possible to change the shape of an image in a strictly controllable way. This can be done by rearranging the sequence of fibres at one end. A square picture, for example, can be rearranged into a thin line, by having the fibres in a square array at one end and arranged side by side in a line at the other.

Fibre bundles that are used to change the shape of an image are called image transducers. Flexible fibre bundles used to see into inaccessible places are called fibrescopes. There are two other types: "light guides" and "light pipes." The latter are bundles in which the fibres are randomly arranged; they are used simply to transmit light intensity or colour. Light guides are fibres with diameters comparable to the wavelength of light—they are the optical counterpart of radio wave-guides.

FIBRESCOPES

A fibrescope produced by Bausch and Lomb Incorporated is illustrated in Fig. 4. The bundle of fibres is 39 in long and is wrapped in an articulated rubber casing for protection. There is an eyepiece on one end and a choice of three objectives can be screwed on the other. The picture area at each end is $\frac{3}{16}$ in square; 15 micron diameter fibres are used, and provide a resolution of 20 line pairs per millimetre. Bausch and Lomb offer it at $300 to people who want to experiment with fibre optics.

Bausch and Lomb's activity in the fibre optics field has been confined primarily to work on such long flexible bundles. They can produce bundles with cross-sections up to 1 in by 1 in, and up to 12 ft long. Such large bundles, however, lose their flexibility and become quite heavy.

The company feel that the whole field of fibre optics is very much in the development stage. They are convinced that for quite a while fibre optics instrumentation will continue on a one-off basis. This is because discussions with possible users have very strongly pointed out the fact that each person has a different idea as to what is wanted. About the only thing they have approaching a stock item is the bundle described above. In the medical field, the company have made one prototype duodenoscope and have a second model nearing completion. They are also working with various people to develop flexible instruments for industrial inspection of such things as boilers, turbines and cylinder heads. Fibre optics looks like having a very big future in this area.

Fig. 2 Using a fibrescope with a built-in illuminator. The cut-away portion shows how the fibrescope penetrates into otherwise inaccessible places.

Other firms working on flexible endoscopes for medical purposes are the American Optical Company and American Cystoscope Makers Incorporated. Prototype instruments for examining the stomach and parts of the kidney have been built. The main advantage of such devices is that they are likely to be very narrow and flexible, so causing less discomfort than other instruments. This requirement also sets the main technical problems in such devices, namely the production of very thin uniform fibres to give sufficient resolution in bundles as narrow as 2 mm.

Another application of fibrescopes is in the stabilization of airborne television cameras; or rather, the lens of the camera. Whereas in a conventional arrangement a television camera in an aircraft has to be stabilized as a whole, by the insertion of a flexible fibrescope between the lens and the camera it becomes only necessary to stabilize the lens. This means the stabilization equipment is very much smaller—a very important consideration for certain types of aircraft or rockets. The Radio Corporation of America have used a 24 in long bundle containing 350,000 elements for one airborne application.

FIBRE SPECIFICATION

A flexible fibre bundle having a useful cross-section of 0·3 in by 0·4 in and made up of 0·002 in fibres (50 microns) will contain about 30,000 fibres. If each fibre is considered to contain one image element, this is a fair quality picture. But it does not contain nearly as many image elements as are often found in other systems. A television picture, for example, has about 200,000 image elements, while the field of a microscope may have 500,000. If the above fibre bundle were made up of fibres 15 microns in diameter, the number of image elements transmitted will exceed 300,000; that is, better than television quality but short of microscope quality.

When such glass fibres are gathered together into a tight bundle to give a high-quality picture, another problem appears. Wherever two fibres come within about half a wavelength of light from each other, some light will leak from one fibre to the other. If the fibres are small and closely packed, they touch over an appreciable area and this leakage becomes a serious problem. For this reason, it has been found valuable to insulate the fibres from each other by a thin jacket of transparent material whose refractive index is lower than that of the fibre. An addi-

tional advantage of the thin jacket is that it protects the wall where total internal reflection takes place, keeping it smooth and clean.

A material for use in fibre optics must have a very high internal homogeneity and a very smooth skin. In addition, a cladding material must be available that will wet the surface and form a tight bond. The American Optical Company have studied plastics but find that in general they have a scattering structure that makes them inefficient in long lengths. Optical glass was found to be the best material and the company have developed machines for drawings the required diameters of fibre. An advantage of glass is the wide choice of refractive indices available. It is now used for both the fibre and the coating material.

The quality demanded of glass in fibres is high, for the path lengths are usually greater than those found in conventional optical instruments. This means that the glass must be quite free of stones and bubbles and must be water white. This last requirement is not always compatible with a high index of refraction, for most high-index glasses are slightly yellow. In the visible spectrum, a 7 ft length of glass fibre produced by the American Optical Company transmits about 50 per cent of the light that enters the ends. About 80 per cent of the light incident on the bundles enters the fibre. The rest hits the space between the fibres or is reflected.

FUSED FIBRE FACES

Calculating the steepest ray that will be trapped in a glass fibre is fairly easy. It shows that in comparison with a normal camera lens, the fibre bundle has a very high speed: f/0·57, for example. This feature can be used to great advantage in television cameras and cathode ray tubes, as vacuum-tight fused bundles of fibres have been developed as replacements for conventional tube faces.

A conventional cathode ray tube has the phosphor on the interior surface of the tube face. If a signal is displayed on this phosphor and a sheet of photographic film or paper is pressed against the glass face of the tube, a blurred record of the signal can be obtained. When a precise record is needed, a lens must be used to focus the light from the phosphor on to the photographic film. If the glass face is replaced with many thousands of glass fibres arranged perpendicular to the face and fused together into a solid mass, each fibre will pick up the light from the phosphor at its interior end and deliver it without parallax to the outside end.

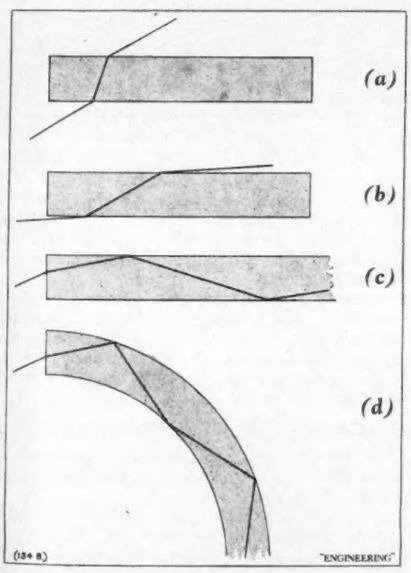


Fig. 3 Because light rays are bent as they cross a glass-air boundary (a), there is a certain angle at which the light can no longer emerge from the glass (b). When this angle is reached in a glass rod the ray is reflected repeatedly and remains in the glass until it reaches the end of the rod (c). The same thing happens in bent pieces of glass (d), and light can be made to travel around curved paths. A ray of light in a 50 micron diameter fibre may be reflected 3,000 to 4,000 times per foot.

If the fibre has a high refractive index, steep rays of light, which would not be caught by an ordinary lens, will be trapped and transmitted to the recording medium. For this reason the optical efficiency is substantially higher than in a lens system. In the tube shown in Fig. 5, a 50 fold gain in speed over a recording camera with an f/2 lens (used at equal conjugates) was achieved. In addition the resolving power of the picture is preserved down to about one or two fibre diameters, which may be a few thousandths of an inch or less. Pictures can be taken in a short time on a cheap photographic medium.

The American Optical Company have developed methods of making such fibre optics faces. Round ones up to 2 in diameter and rectangular ones ¼ in by 8 in have been produced. Larger tube faces can be made by fusing together small blocks of fused fibres.

OPTICAL TRANSDUCERS

There are some applications where the ability to rearrange the elements of an image can be used to speed up the sensitivity of fibre optics systems still further. This has led the Radio Corporation of America to develop to a new high-definition aerial surveilliance system that looks like having application in earth satellites and space probes.

In an existing form of aerial reconnaissance camera a picture of the ground is focused through a slit on to a moving strip of film, much in the same way that a photo-finish of an important race is obtained. The very high resolution of modern films makes the use of a narrow slit image possible. However, television cameras do not have such high resolutions and have not been adaptable to this method. Fibre-optics image-transucers now alter this situation. The film is replaced by an image orthicon camera and a fibre bundle is connected to it. At the slit end of the bundle the fibres are arranged as a single line; at the camera end the fibres are arranged in a square lattice, or "raster." This change of shape enables the image orthicon to record the slit image at high resolution. Signals from the tube are transmitted by an appropriate carrier wave to ground, where the raster is reproduced on a cathode ray tube. A second image transducer, identical to the first enables the slit image to be restored and recorded.

In military applications, the way in which the fibres were arranged in the raster would be secret and it would not be possible for an enemy to know what was being sent.

This encoding property of image transducers has a number of applications. The simple transition from a slit to a raster is likely to have application in high-speed facsimile equipment for the long distance transmissions of drawings and photographs. The reverse transition is likely to be of use to the astronomer. Spectrographic equipment, for example, needs its light input to be such as is obtained through a narrow slit. If use is simply made of a slit to do this, much light is lost. An image transducer can avoid such loss.

A random rearrangement of fibres can be used to identify a signature on a cheque. If the customer's correct signature is passed through such a transducer and the resulting distorted image printed on the face of the cheque book, a counter clerk can always cheque the signature on a customer's cheque for cash by comparing it with the cheque book, provided he looks at it through the same arrangement of transducing fibres, which would be special to the bank.

If the diameter of a fibre changes gradually along its length, the light trapped in it will be concentrated or spread out. If an orientated bundle of fibres with an image at one end is tapered, the image will be reduced or enlarged at the other end. It will be found that the light coming from an enlarged image is more nearly collimated than the light from the original image, and vice versa. This arises because the taper of the wall tends to change the angle of each ray as it is reflected. In optical terms, the fibres are found to obey the Abbe sine condition. If a lens illuminates the large end of a tapered bundle and a film is put at the small end, the effective photographic speed of the lens is increased.

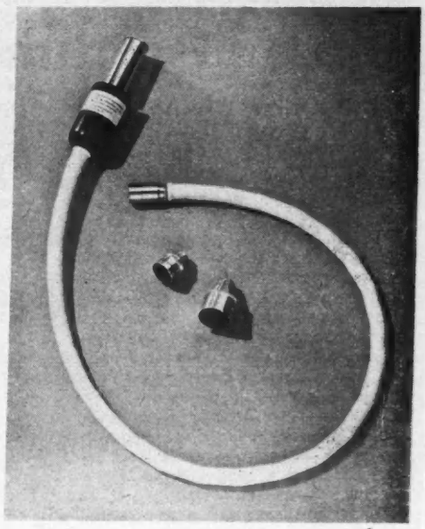


Fig. 4 This fibrescope is 36 in long and is equipped with an eyepiece and three objectives.

The change in angle of rays of light inside tapered fibres means that light can enter an expanding fibre from the sides and become trapped in it. For this reason it is better to paint tapered bundles used for magnification black, as stray light lowers the image contrast. American Optical make tapered bundles as large as 2 in across at the big end and having fibres as small as 2 or 3 microns at the small end.

Light pipes consist of bundles of fibres in which the lost area between fibres is minimized and no attempt made to arrange the fibres regularly. For this reason they are much cheaper but cannot be used to transmit images. They do, however, have a number of uses. A light pipe can be used to provide illumination at the inaccessible area being inspection with a fibrescope. They are also useful where indications of light intensity or colour is all that is required. They can pipe such information from situations where heat and vibration make direct installation of a photocell impossible. One such application is monitoring of jet engines.

When the diameters of fibres are reduced to the order of the wavelength of light, geometric optics can no longer be used to describe the transmission that takes place. Light is then transmitted in various wave modes. Such light guides are being studied for possible use with optical masers.

Fig. 5 The fibre-optics face plate of the cathode ray tube gives a 50 fold speed gain over a recording camera with an f/2 lens.

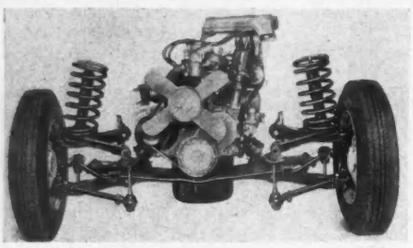
Fiat Produce New Range of Models

By making changes to their existing models and introducing new engine sizes, Fiat have effectively introduced a new range of cars.

By Gordon Wilkins

Though orthodox in conception, the Fiat 1300 and 1500 are well designed cars with a remarkably high performance. They are the first in this category to have disc brakes, which are Girlings made under licence in Italy being used on the front wheels.

The style of the four-door saloon body, with its four headlamps and high all-round waist moulding seems to be derived more from the Chevrolet Corvair than from Italian sources, but it provides a large enclosed volume, giving roomy seats for four and a large boot in a car only 13 ft 2½ in long and 5 ft 0¾ in wide. The engines have an exceptionally high power output, and acceleration is outstandingly good for this class, with maximum speeds of 89 mph



Front suspension linkage of the Fiat 1300 with Girling disc brakes.

announced for the 1300 or 95 mph for the 1½ litre car. These two models appear to be the equivalent of the American compact car in European terms, appealing to many owners who are tired of struggling with larger cars on increasingly congested roads.

Originally the engines were simply four-cylinder versions of the 1800 and 2100 sizes, having swept volumes of 1,197 and 1,369 cc, and designed to use exactly the same machining facilities; but in the search for better low-speed performance, the stroke was increased from 73·5 to 79·5 mm and the inlet valve diameter went up from 29 to 31 mm. With the 72 mm bore the 1300 engine, which is intended mainly for countries like Italy where taxation is based on engine size, has a capacity of 1,295 cc. A twin-choke downdraught carburettor with differential throttle control is mounted on one side of the eight-port head and on the opposite side is a complex cast exhaust manifold taking the outputs from cylinders 1 and 4 and 2 and 3 into paired pipes which only join into one tail pipe at some distance from the manifold.

1300 AND 1500 RATINGS

Valves are operated by cross-over pushrods from a single camshaft and set at an angle in a "polyspherical" combustion chamber, the contours of which are largely chosen for ease of machining by tools taking their location from the valve guides. The timing gives a 30° overlap between inlet opening and exhaust closing. Compression ratio is 8·8 to 1 and the 1,295 cc unit gives a CUNA output, less fan and silencer of 65 bhp (72 SAE) at 5,200 rpm with net torque of 68·7 lb-ft at 3,400 rpm (76 lb-ft SAE).

The 1500 unit has bores of 77 mm to give 1,481 cc and gives a CUNA output of 72 bhp at 5,200 rpm (80 SAE) with maximum torque of 78 lb-ft at 3,200 rpm (86·8 SAE). The lubrication system includes the Fiat centrifugal filter in the fan pulley, and a bypass paper element filter. Oil passes from the centrifugal filter through internal oilways machined in the forged crankshaft. Bench testing included endurance runs of 1,000 hours and cycles of ten hours between 5,000 and 6,000 rpm.

The gearbox has four forward speeds, constant mesh and all synchronized, reverse is provided separately in an extension of the casing. Gearbox testing included a bench run equivalent to 125,000 miles with thousands of hours at 40 per cent over maximum engine torque. Synchronizers to each gear had to show no wear after 50,000 consecutive engagements at 4,000 rpm. There is a divided propeller shaft to reduce tunnel height. The rear axle is a conventional hypoid unit and for rear suspension Fiat have reverted to asymmetrical half elliptic springs, after the more complex but little more effective arrangements used on the 1400 and the current six-cylinder models.

Front suspension is by coil springs and wishbones, with ball joint steering pivots, the coil spring and concentric damper being carried between the upper wishbone and an abutment in the wheel arch. A light detachable cross member carries the pivots for the lower track control arms which are completed by diagonal ties running forward to ball joint pivots. There are also anti-roll bars at front and rear. The worm and roller steering and the associated linkage are well protected behind the cross member. Front brakes are discs of 9·3 in diameter, shrouded against mud and grit and the rear drums are 9·8 × 2·16 in made in aluminium, radially finned with bonded iron insert. No Baldwin booster or pressure limiting valve is employed.

The unit structure is designed to give approximately the same accommodation as the six-cylinder models in a much more compact vehicle. Two box section members run forward from the floor and the wheel arches are reinforced for the spring abutments. A fixed panel at the back of the luggage trunk adds torsional stiffness and carries the number plate, but increases the height through which the luggage must be lifted. The spare wheel lies in a well in the floor.

The facilities of the Fiat aircraft division were used for the study of structural vibration and led to small changes which reduced the amplitude of bonnet vibration to one-eighth and that of the front wings to less than a tenth of previous figures. Dry weight is 2,028 lb.

In all, 19 prototypes covered 932,000 miles, from the Arctic Circle to Somaliland. Each prototype did at least 40,000 miles on the Autostrada del Sole at sustained cruising speeds of 84 mph and this led to intensive development of bearings, pistons and tyres. In fact, Pirelli and CEAT have evolved special tyres for this model.

The unusually comprehensive equipment includes warning lights for choke and handbrake and grab handles in the roof. Overlapping windscreen wipers swing outwards and a cam action linkage sets the upper one moving faster as they swing up from rest. A pedal brings wipers and screen washer into action simultaneously. Switches are of the rocking piano-key type already used on the German Fords and special care has been taken to eliminate all needless projections from the interior. Door handles are concealed under the armrests and exterior handles are flush fitting. Little chassis lubrication is required beyond attention to steering ball pivots at 10,000-mile intervals.

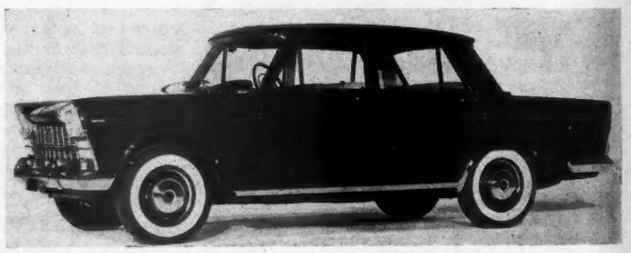
2300 DEVELOPED FROM THE 2100

Fiat has completed an extensive redesign of their 2300. It is identified by the four headlamps neatly built into the existing front. Its engine has been increased to 2·3 litres, and now gives 105 hp installed in the car, sufficient to guarantee a speed of 100 mph. British Girling disc brakes with vacuum servo are fitted on all four wheels, and the de Normanville overdrive made in Italy by Bianchi is now offered as an optional extra. Later, a fully automatic transmission or an automatic clutch will be available. An interesting feature is the electric magnetic clutch which stops the engine cooling fan when it is not needed. This cuts down engine noise at fast cruising speeds, helps quick warming up and should improve fuel consumption.

Fiat engineers have abandoned the rather complicated rear suspension, with coil springs and laminated spring radius arms, which personally never appeared to give results commensurate with the extra cost and complication. They have adopted a strictly orthodox rigid axle, with conventional semi-elliptic springs and an anti-roll bar, which increases rear seating space and trunk capacity.

In the new engine bore and stroke have been increased to 78 × 79·5 mm giving 2,379 cc. Compression ratio is unchanged at 8·8 to 1, but crankshaft, pistons and manifold are new.

The inlet valves are larger and the twin-choke carburettor has differential throttle control.



New Fiat 2300 develops 105 bhp to guarantee a speed of over 100 mph.

Maximum useable power is now 105 bhp at 5,300 rpm (117 bhp SAE) with torque of 123 lb-ft at 2,800 rpm (134 lb-ft SAE). Gearbox and rear axle have been strengthened and tyre size is increased to 6·40.

Instrument and switch layout has been modified. The intensity of the turn indicator warning lights is automatically reduced when the external lights are on, to prevent dazzle to the driver at night. A fan to demist the rear window is an optional extra.

ALTERATIONS TO OTHER MODELS

On the station wagon the front suspension is redesigned and the new rear suspension permits a lower floor level.

The 2300 special saloon replaces the 2100 limousine which already had four headlamps. It is similar in appearance, but the body has been extensively modified and wheelbase has been increased by 3 in. Electric window lifts are optional but a rear window defroster is standard.

Many of the changes appearing on the 2300 apply also to the latest 1800, known as the 1800B. It has the disc brakes and new rear suspension and the interior improvements, but does not have four headlamps. Engine modifications raise the output to 86 bhp at 5,300 rpm (97 bhp SAE) but the capacity is unchanged.

Human Element

Predictable Pattern in Component Replacement

A RESEARCH student holding a Fellowship founded in honour of a Dunlop director has been awarded a doctorate for a thesis which may help Dunlop, and other motor accessory manufacturers, to plan their production schedules better. He is Dr. Charles Kendrick, recently the holder at Birmingham University of the Kenward Memorial Fellowship, set up in 1948 in memory of Sir Harold Kenward, a director of the Dunlop Rubber Company.

Dr. Kendrick's research, based on a close study of a number of vehicle components, including tyres, has confirmed that these components become due for replacement according to a predictable pattern. Generally speaking, a few will be damaged or wear out, and will have to be replaced, early in life. The number of replacements will increase to a peak after several months or years, but a few of the components, gradually diminishing in numbers, will continue in service for much longer. From this information, which has to be studied for each individual product, a standard probability curve can be constructed. By taking each month's sales and aggregating the curves for replacements arising out of those sales, it becomes possible to predict with considerable accuracy the total replacements that are likely to be needed for any month far into the future.

These facts have, of course, been recognized for some time; but it is doubtful if they have been studied before so extensively.

Dr. Kendrick took his B.Sc., in Mechanical Engineering and M.Sc. in Engineering Production and Management at Birmingham University and is now working in the Quality Control Department of Joseph Lucas Limited.

Bracknell New Town Expansion Approved

A modified version of the proposed extensions to Bracknell New Town, in Berkshire, is to be carried through, giving an eventual population of more than twice the present planned 25,000 maximum.

Objections to the Minister of Housing and Local Government's order by which it was planned to add 1,230 acres on the western and southern sides of the new town were heard at a public inquiry last February.

The Inspector who held the inquiry reported that, apart from one written objection, no issue of principle had been raised by any local authority representative. There was, however, virtual unanimity against the proposed inclusion of a salient to the south-west.

In his letter setting out his decision, Mr. Henry Brooke, the Housing and Local Government Minister, refers to the necessity of steering development wherever possible to land of lower agricultural value. It was this consideration that led to the intention to develop the south-west salient and avoid taking land to the same extent to the west of the town. In view of all the representations it is now decided to cut down the south-west salient and to designate a compensating area of land to the west of Bracknell.

Mr. Brooke's letter concludes; "the Minister's intention now is to make the designation order as he had proposed it, but omitting from it some 150 acres from the south-west salient shown in the draft order. He also intends to formulate fresh proposals for designating approximately 160 acres of land to the west of the town and, if and when the Crown Estate Commissioners are empowered to dispose of any of their estate, for designating some part of the Crown Estate land to the south-east of the town also."

The Beama Electronics Board

The BEAMA Council has established an Electronics Board to represent that part of the BEAMA membership directly concerned with electronics engineering. This new Board will act for the BEAMA Council on matters of broad policy in this field and it will provide the necessary high level liaison with Government Departments and other Associations on policy matters affecting the electronics industry. The initial membership of the Board is as follows:—

Mr. Leon Bagrit (Elliott Bros.)—Chairman
Mr. O. W. Humphreys (GEC)—Vice-Chairman
Mr. E. B. Banks (English Electric)
Mr. W. S. Steel (AEI)
Mr. Sebastian de Ferranti (Ferranti)
Mr. C. Metcalfe (EMI)
The chairman of the BEAMA Industrial Electronic Equipment Section, at present Mr. W. Gregson (Ferranti), is also a member of the Board.

These arrangements are designed to provide within the framework of the BEAMA an organization to safeguard the interests of British manufacturers concerned with electronics engineering, but it is not intended to assume on behalf of BEAMA members responsibility for other sectors of the electronics engineering industry, e.g. telecommunications and components, which are already dealt with by existing Associations. The Board will, however, cooperate with the governing bodies of such other Associations whenever policy matters affecting the electronics industry as a whole call for representations at top level.

Future Development in the Dip. Tech.

The Regional Advisory Council for Technological Education for London and the Home Counties, the body formed after London County Council conferences, on the initiative of the Ministry of Education, shortly after the war, has prepared a plan for the orderly expansion of courses leading to the Diploma in Technology. The central aim of the scheme is to maintain the high standard of the Diploma (equal to an honours degree), and one of its essential tenets is that over-provision of Dip. Tech. centres must be avoided.

The Regional Advisory Council proposes that existing courses which are running satisfactorily shall be developed up to an agreed figure of first-year enrolments. These "review points" are set out in the detailed synopsis given in the Council's Regional development plan for courses for the Diploma in Technology.

Only when these agreed figures have been reached would consideration be given to new Dip. Tech. courses and the enlargement of the existing courses. When this point is reached the colleges are liable to have to move fast, for a major influx of 18 and 19 year olds is due in 1964 and 1965.

Enlargement Plans

In nine separate sections, the development plan is as follows. Dip. Tech. courses in chemistry; existing courses at Battersea, Northampton, Borough and Brunel had a total first year intake of 51 students in 1960/1961. These courses should be allowed to develop up to a first-year intake of 130. Keeping this situation under review, proposals for new courses at Woolwich and Kingston should be considered as soon as the need becomes apparent.

Chemical engineering: the existing courses at Battersea enrolled 10 students during the first year in 1960/1961. These courses should be allowed to reach a first-year intake of 30 students. At the appropriate time, the conversion of the A.M.I.Chem.E. sandwich course at West Ham to a Dip.Tech. course should be considered.

Applied mathematics: the Battersea, Northampton and Brunel courses had a 1960/1961 first-year intake of 46 and this level should rise to 80. There are no new courses proposed at the moment and it is not expected that any will be required for the next four or five years.

Applied physics: the courses at Battersea, Northampton, Borough, Brighton, Brunel and Northern had a first-year intake of 125. These courses should be allowed to reach a first year intake of 210. In every case, two parallel or end-on courses are recommended. Proposals for new courses at Woolwich, West Ham, the Regent Street Polytechnic, and Kingston should be considered when there is a clear need.

Civil engineering: the Battersea, Northampton and Regent Street Polytechnic courses had a total first-year intake of 40. These should be allowed to develop up to 110 and, in each case, two parallel courses are recommended. Proposals for courses at Brighton, Kingston and South-West Essex (Walthamstow) will be kept under review.

Electrical engineering: the total first-year intake of the courses at Battersea, Northampton, Borough, Brighton, Brunel and Hatfield, the Regent Street Polytechnic, and at Woolwich was 185. This total should be allowed to rise to about 370 and two parallel courses are recommended for all but Brighton, Hatfield and the Regent Street Polytechnic, where it is suggested that an initial review should take place when one intake each year is filled approximately to capacity. Proposals for new courses at Hendon and Kingston in 1962 should be considered in the light of enrolments in existing courses in 1961/1962. If these two additional courses are approved, total annual first-year capacity will rise to over 400 places and it will then be unlikely that more courses will be needed before 1964/1965.

Aeronautical, mechanical and production engineering: the aeronautical courses at Northampton, Hatfield and Kingston, with an expected first-year capacity of 90 places, are thought likely to be sufficient for the next four or five years. No new courses have been put forward in this region.

The Battersea, Brunel, Northampton, Hatfield and Woolwich existing courses had a first year 1960/1961 intake of 130. These should be allowed to increase to a total of 350. Two parallel courses are recommended in all cases except at Hatfield where a review is suggested when one annual intake is filled to its capacity. A new Dip. Tech. course which will replace an existing degree or college diploma course at Brighton in 1961 or 1962 is recommended. Within the same period proposals for new courses at Borough, Hendon, the Polytechnic Regent Street, and Kingston should be considered in the light of current enrolments in courses and with reference to the numbers reached at neighbouring colleges.

The metallurgy courses provided at Battersea and Brunel, with a total first-year capacity of about 60 places, are adequate for the next four or five years.

Further Consideration

Brunel's existing applied biology course, whose annual first-year intake is about 15 students, is the only Dip. Tech. course of its kind in the region. It should be allowed to increase to an annual intake of about thirty students. There are no proposals for additional courses.

Applied biochemistry and applied pharmacology at Chelsea had a first-year intake of 13. The development scheme suggests that these courses should be allowed to develop up to about a total of 30 in the first-year intake. No new courses in the region are proposed. The possibility that a course in biochemistry may be proposed at South-West Essex (Walthamstow) in the next few years should be borne in mind.

The plans drawn up by the Regional Advisory Council, after consultations with industry, the Ministry of Education and the local education authorities in London and the home counties, have themselves to be considered and approved by the National Council for Technologic Awards and the Ministry of Education before they may be put into effect.

Class of 1961 a Well Paid Lot

Starting salaries of this year's graduates of the New Jersey, USA, Stevens Institute of Technology have reached the record height of $543 (£194) a month states the Institute's news bureau. Those in the top quarter of their final class received an average of slightly more.

The Institute's assistant replacement director, Laurence Minck, believes that United States industrial companies, contrary to popular belief, are resting heavily in their selection upon marks alone.

"Companies are not necessarily looking for the 'well rounded man.' Extra-curricular activities help, but high competence in engineering and science is the most important factor to industry," says Mr. Minck.

Students starting their careers were also offered increased pay by Federal Government employers. Those entering the government service who had graduated in the upper quarter of their class, or with a B average, received $80 a month more than other engineers and scientists just beginning.

Europe's Longest Arch Bridge Completed

No large bridge can be built without calling heavily on past experience, nor can it be done without making a new contribution to the art.

EUROPE'S longest arch bridge, and the third longest in the world, was opened to traffic on 21 July. It crosses the River Mersey and the adjacent Manchester Ship Canal to make a permanent road connection between the two towns of Runcorn and Widnes and has been built to replace an old transporter bridge which is to be dismantled as soon as possible—a ticklish job if shipping is not to be disrupted.

The span of the bridge, as shown in Fig. 1, is 1,082 ft. The bridge, designed for the heaviest road traffic, has a single 33 ft carriageway and two 6 ft pathways (Fig. 2). It is a conventional steel arch with symmetrical tail spans and the superstructure consists of two open-web trusses at 54 ft centres joined by cross bracing. About half of the 5,600 tons of the steel in the superstructure is of high tensile steel, including the chords of the arch and the main cross girders and stringers for the deck. Locked coil ropes, the heaviest of them able to take a load of 180 tons, have been used to suspend the deck from the arch. The nearly completed bridge, with the railway bridge in the foreground and the old transporter bridge partly hidden by the new arch, is shown in Fig. 3.

The bridge has been built to the joint orders of the Lancashire and Cheshire County Councils and the consulting engineers are Mott, Hay and Anderson of London.

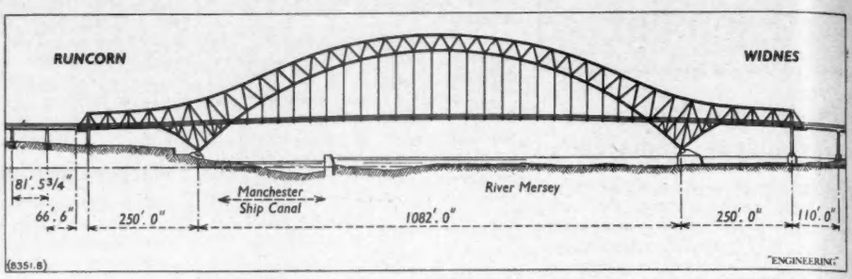


Fig. 1 (above) Principal dimensions of the Runcorn-Widnes bridge.

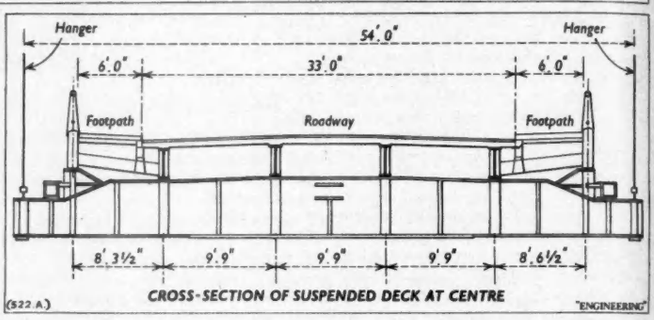


Fig. 2 (right) Cross-section through the deck at mid-span.

HISTORY

The history of the bridge is a curious one. When it was finally decided that the transporter bridge had to be replaced the first intention was to build a new bridge that closely resembled the nearby railway bridge, a fine structure with very close interlacing cross bracing in the main girders which are still in excellent condition, although nearly 100 years old. This bridge has three simply supported spans of about 300 ft with two piers located in the middle of the river. For economy and to facilitate erection, the new bridge would have been made continuous over the piers.

The location of one of the piers of the new bridge would, however, have been very close to the wall of the Manchester Ship Canal and the Canal Company objected to the nearness of the pier, demanding protection which would have considerably raised the cost of the work. (The fact that the pier of the railway bridge was also close to the wall of the canal was a matter of historical order, for the railway bridge was built before the canal.)

Because of the objections, the decision was taken to construct a suspension bridge which spanned the canal as well as the river. A design was completed and tests were carried out at the National Physical Laboratory to investigate the effect of the nearby railway bridge on the aerodynamic buffetting the new bridge might suffer and the engineers produced a sound design to meet this. Local public opinion, however, was persuaded by a television programme which included a film of the Tacoma bridge collapse that there was still a considerable risk attached to a suspension bridge, and the authorities were obliged to adopt a different type—a change that entailed a new Act of Parliament.

Several years before, the consulting engineers had made a preliminary study of the bridge as a two-hinged arch span in steel—without tail spans. It is of interest to note that the cost of a light alloy bridge was found to be comparable with, though higher than, that of the correspond- steel arch. But the rigidity would have been insufficient to meet aerodynamic buffeting.

When public opinion demanded the change from a suspension bridge, the steel arch design was revived. But in the design of the bridge as built, side spans of 250 ft are made continuous with the arch. This continuity is the major factor which gives the bridge a considerably superior " resistance " to aerodynamic buffeting over that of a simple arch or a suspension bridge. The continuity also resulted in economy in steel in the side spans and facilitated the arch erection in its early stages.

Fig. 3 The nearly completed bridge with the railway bridge in the foreground. The old transporter bridge which is shortly to be demolished is partly hidden by the new structure.

PROPORTIONS

When the project was first under serious consideration, dual carriageways 22 ft wide, cycle tracks and footpaths were provided for. At the time the suspension bridge was designed the national financial stringency resulted in the accommodation being reduced to only one carriageway and one footpath. However, as the arch design necessitated a width of some 50 ft between trusses for stability of the structure as a whole, a road width of 30 ft was considered to be more in keeping. Subsequently, to give greater safety for traffic, this was increased to 33 ft. There is a 6 ft footpath with removable paving on each side under which numerous services, such as high pressure gas and water mains, GPO cables and the like have been, or will be, installed.

A great deal of attention was given to obtaining a pleasing line for the arch. Panel size was carefully considered as was also the inclination of the non-vertical members of the spandrels above the piers. The lower chords follow a circular arc of about 780 ft and the rise of the arch is 253 ft. At the springings the depth of the trusses is 106 ft but this reduces to 35 ft 3 in at the crown. The profile is best seen in Fig. 1; the scale of this drawing is too small to show it, but the line of the top chords is much improved by having two straight chords as a transition between the curves above the springings and the reversed curve over the arch. A very pale green paint has been used on the superstructure which

does a lot to enhance the apparent lightness of the design.

A previous article (ENGNG., 29 July, 1960, p. 148) described the method of erection used for the arch and gave some details about the reinforced concrete structures forming the approaches. Note was also made there of the advantages which accrued from the use of temporary lifts at each end of the structures, greatly reducing the task of supervising and inspecting the work.

All joints in the main chords are machined. Site joints were riveted. High tensile bolts were considered but not adopted, because, at the time the relevant decision was taken, some seven years ago, it was considered that there was not sufficient experience to justify their use in such a heavily loaded structure.

EXPANSION JOINTS

The deck steel, which is mostly of high tensile type, is welded throughout and the stringers are continuous between the main expansion joints, which are about 800 ft apart. All the cross girders were stress relieved in furnaces and a very high proportion of the site welds on the stringers etc. were tested. The cross girders are some of the largest girders ever stress relieved, being made largely of 1¾ in plate and, in places, of 2 in plate and over 55 ft long.

The expansion joints in the road deck are of a novel kind designed by the consulting engineers; British and foreign patents have been taken out. The form of the joint is indicated in Fig. 4 and consists of a series of alternate steel flats and rubber pads which, even under normal conditions, are considerably compressed; the pads are able to accommodate all possible expansion in the bridge without breaking contact with adjacent steel and are also able to accept more compression as well as some bowing in any plane. Their action can be likened to that of a concertina. The great advantage of this form of joint over the more familiar steel combs is that it is water-proof and will not allow water—and dirt—to penetrate to the steelwork below which, at an expansion joint on a large bridge, is particularly complex and difficult to maintain. Such a joint is also less likely than the steel comb type to be the cause of vehicles skidding.

On each of the main joints of the Runcorn-Widnes bridge there are 42 such units, each unit,

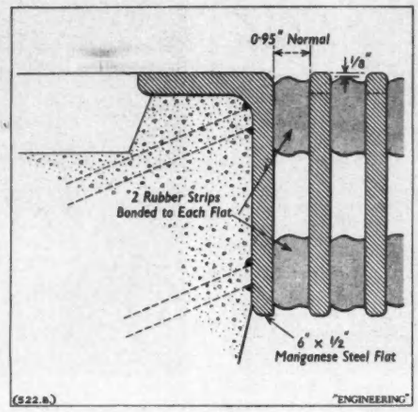


Fig. 4 The steel flat and rubber insert units used in the deck expansion joints.

comprising two rubber pads bonded to a manganese strip, laid side-by-side to form a joint 5 ft 1 in wide that is able to accommodate a movement of 4½ in either side of the normal. The units themselves are supported on a phosphor-bronze bearing strip and restraining strips are incorporated to ensure that units cannot jump out of place. The Andre Rubber Company supplied the rubber and were responsible for bonding it to the steel flats. The short experience so far available shows that the joints are working very well and causing no trouble to traffic.

Altogether there are three sets of expansion joints at each side of the bridge. The main joint, which has to absorb both thermal and wind load distortion, is located just inside the lower chord of the arch; a second at the rear of the spandrel, to take up some high local strains to which the deck is liable at this point; and a third where the tail span links with the approach viaduct.

Prior to painting, all the steelwork not metal sprayed in the shops was flame cleaned *in situ*, the largest job of its type so far undertaken in this country—60,000 sq. ft of steel being so cleaned. This work was done by the painting contractor, Thomas Cotton Limited of Mansfield, using British Oxygen equipment. For the future maintenance of the bridge, two painting gantries have been installed on the structure, one being slung below the deck and the other arranged so that it can be hauled over the crown of the arch. To minimize any risk due to lightning, the whole structure is earthed at both ends.

Altogether, the period of construction was 1,912 days—5¼ years—from the date that the civil engineering contractors, Leonard Fairclough of Adlington, began work on 25 April, 1956. Fairclough were awarded the original contract for the bridge substructure (the two main skew-back foundations, the piers supporting the side spans) and, as subcontractors to Dorman Long, were responsible for the approach viaducts and for laying the concrete deck on the bridge itself.

The steel arch was completed in 1,055 days from 1 September, 1958, when Dorman Long began work on the site. At no time were more than 250 men working on the site, of which only 30 were riveters, 8 welders, and 6 scaffolders.

OTHER STEEL ARCHES

As already mentioned, the bridge is the largest of its type in Europe and the third largest in the world. The spans of the longest steel arch bridges, their locations and dates of completion are given in the following table.

	Name	Location	Span (ft)	Year
1	Bayonne ..	Kill Van Kull, New York City ..	1,652	1931
2	Sydney Harbour	Australia	1,650	1930
3	Runcorn-Widnes	England	1,082	1961
4	Birchenough ..	S. Rhodesia	1,080	1935
5	Nagasaki-Sasebo	Kyushu Island, Japan	1,042	1955
6	Glen Canyon ..	Arizona	1,028	1958
7	Hell Gate ..	New York City ..	977½	1917
8	Rainbow ..	Niagara Falls ..	950	1941
9	Duisburg-Rhein-hausen	Rhine River ..	838	1951
10	Rohri Channel Bridge	Indus River	806½	Nearing completion
11	Volta	Ghana	805	1956
12	Henry Hudson..	New York City ..	800	1936
13	Inoura Narrows	Omura Bay, Japan ..	710	1955

Steelwork contractor: Dorman Long (Bridge and Engineering) Limited, who also built the Sydney Harbour Bridge.
Foundations and the approaches were built by Leonard Fairclough Limited, Adlington, Lancashire, the former under a separate contract and the latter as a subcontract for Dorman Long.
Consulting engineers: Mott, Hay and Anderson, Iddesleigh House, Caxton Street, London SW1.

Multidek Car Park with Duplicated Access

Aimed at giving motorists a new deal, the Lee Circle development, situated on one of the central areas of the City of Leicester, is designed to provide their essential requirements on one site: parking and service for the car, a shopping centre, entertainment and refreshment.

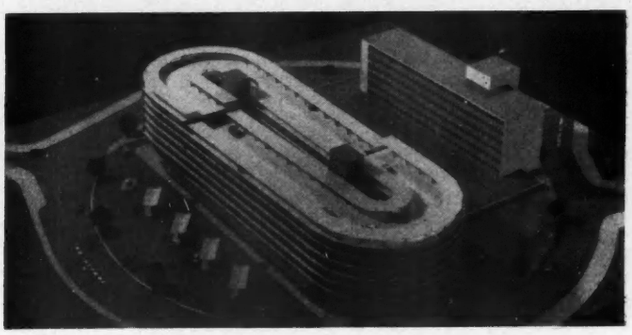
As shown in the accompanying illustration of a model of the development, the complete scheme will comprise the " Multidek " car park capable of holding 1,050 cars, a petrol station with 14 pumps and a forecourt of 16,500 sq. ft, an automatic car-washing plant which can handle 2,000 cars a day, a one-storey 36 lane ten-pin bowling alley, a supermarket, shops, restaurant, and a six-storey office block containing some 50,000 sq. ft of floor space.

The central feature, the Multidek car park, is now nearing completion, and a commencement is expected to be made shortly on the other buildings. Basically, the car park is a gently-climbing road built as a spiral; the ascent being 1 in 10 until parking level is reached and, thereafter, 1 in 32. There are two ramps in this 400 ft long building, each of three decks and climbing in reverse directions; thus, in rush-hour period there are two points of entry and departure, so relieving the maximum density of traffic movements. The supermarket, shops and so on occupy the ground floor.

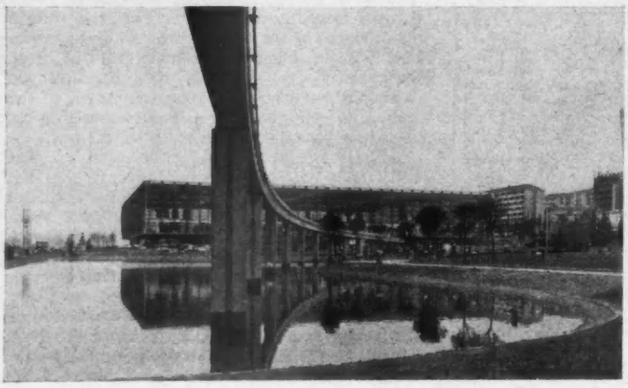
Due to this dual-ramp entry and exit system, the maximum distance that cars can travel is there complete circuits of the building and, once his car is parked, the motorist is within a few paces of one of the four express lifts. Parking is in single ranks at right-angles to the roadway. Each car bay measures 16 ft by 8 ft and is serviced by a clearway road 24 ft in width. The maximum time required to enter the building, park a car and return to street level will be five minutes, but the normal time taken to do this is expected to be between two and three minutes only.

The intake of the car park will be at the rate of 600 cars an hour, 300 at each of the two entrances, and in all, the equivalent of four miles of kerbside parking will be provided. The charges at Leicester are expected to be in the region of 6*d* an hour and from 2*s* 6*d* to 3*s* for a 12 hour period. There is no mechanical handling of cars and no parking by attendants. Motorists drive in, collect a time-stamped ticket, drive to a vacant space and park their own cars, locking them on leaving.

The car park is constructed of reinforced concrete with the ramps supported on columns, beams and precast piles; toilets, washrooms and lifts being provided in the centre of the structure. Multidek car parks are being developed by Multidek Car Park Developments Limited, 8 Clarges Street, London W1, and the building contractors for the whole site are William Cowlin Limited, Bristol. A smaller Multidek car park has been built in Bristol.



Model of Lee Circle building development at Leicester. The flat-roofed single-storey structure separating the double-spiral Multidek car park from the office block is designed for a bowling alley.



The monorail serves the whole of the exhibition.

At night the Pavilion of Labour really comes into its own.

British Research Displayed to Italians

Ten years after the Festival of Britain, Italia '61 provides British industry with another opportunity to show her wares in direct competition with the other exhibiting nations.

By Richard Bailey

THE Centenary of the unification of Italy is now being celebrated in Turin, where the first Italian Parliament met 100 years ago. The main celebration is the exhibition, Italia '61, which is being held in a pleasant park on the banks of the River Po. This exhibition, which lasts until October, is in three parts of which the International Labour Exhibition is likely to prove of most interest to British visitors for two main reasons. The first is that it is housed in the spectacular glass and concrete building designed by Pier Luigi Nervi and the second is that different aspects of the general theme of the exhibition "Men at Work" have been handed out to the various countries represented, making it possible to compare the showing of the designers of the national stands.

The Pavilion of Labour would be worth a visit on its own account even without the very interesting exhibits which it contains. It is supported on 18 columns each bearing a square section of the steel roof. The sections are separated from each other by a strip of glass. The columns, each 75 ft high, are of great beauty and make the Pavilion into one of the most exciting of modern buildings.

The need to fit into the organizers' ideas on the treatment of a single theme tends to make the task of the national exhibitors very difficult and a great deal depends on the luck of the draw. Great Britain has been fortunate in drawing "Scientific Research" as its subject. Not all the other countries have been so fortunate. The main interest to judge by attendances is divided fairly evenly between the American, Russian and British stands. As Italia '61 is an exhibition and not a trade fair, the responsibility for designing the British exhibit falls on the Foreign Office but the actual preparation of the stand has been carried out by the Central Office of Information.

PUTTING BRITAIN OVER

The theme of Scientific Research clearly calls for a careful selection of subjects to illustrate and the choice, here, has on the whole been successful. The problems of heredity, the hospital operating theatre, the different aspects of modern transport are all interesting in their different ways, though illustration of the principles of heredity by means of a series of visual aids requires rather closer concentration than the average exhibition visitor can give to it. The operating theatre on the other hand compels attention not only because of the human interest of its life-size group of figures, but by the display of modern equipment which it contains.

The application of scientific research in transport provides some of the more interesting parts of the British stand but the working model of the blind landing equipment suffers from the fact that the Americans have a much bigger and more spectacular one on their stand. A cockpit mock-up of the "Vanguard" and the model jet engine with its simulation flames, and the Hovercraft models however are very effective. So too is the model shipyard by Swan, Hunter and Wigham Richardson.

The 18 countries and six international organizations taking part in the International Labour Exhibition have not all succeeded equally well. There is a great temptation to rely too much on visual aids of one kind and another and some of the smaller countries have filled their stands with blown up photographs and many square yards of explanatory text. The effect of all this carbdoard culture is very depressing, especially when the same few words are repeated in as many as six different languages.

What is the value of participation in an exhibition of this kind? Do the results justify the effort and money that have gone into producing the set of exhibits that the Central Office of Information has assembled in Turin for the Foreign Office? The answer must depend to a large extent on how far the British pavilion manages not only to show the development of scientific research, but puts Britain's contribution into perspective. Do the hordes of visitors come away feeling that the British have done anything worthwhile since the time of James Watt and George Stephenson? Within the limits of the task set by the organizers, the design team of the COI has succeeded brilliantly. The British pavilion is one of the three that are receiving most visitors and are being most talked about. The other two are of course those of the United States and Soviet Russia. The British exhibition comes off because there are interesting things to see there and considerable imagination has been used in setting them out. British firms can take a great deal of credit for this particularly for the equipment that they have lent for the show.

All told, the organizers have presented a very favourable image of British achievement. How have the other countries carried out their tasks? The United States pavilion contains rather more machinery and gadgets, but makes few attempts at instructing the visitor on the more abstract aspects of its theme. There is a beautiful full-size mechanized kitchen in which the housewife, by dialling a code on the telephone, can set various appliances to work. One interesting point of presentation is the way in which computers are used in the British and American exhibits. The Ferranti computer on the British stand has been placed at the disposal of Italian universities and research institutes to carry out any work they may require during the period of the exhibition.

The Americans have several IBM computers on view, all performing special tricks. Visitors can select a question from a list on the wall and ask for an answer. In no time at all the machine taps out, in whatever language is specified, such interesting information as the fact that "Over the past ten years the number of foreigners arriving in the US annually through sea and air ports has increased by more than 90 per cent." This is typed out on a special form on the back of which is a blurb about the IBM computer in four different languages. The Russian exhibit is written up only in Italian and Russian and as a result the machine tools, printing machinery and blown up photographs of Yuri Gagarin do not immediately suggest the theme "Security, hygiene and working conditions" to the visitor. The general propaganda impact of the Soviet pavilion is, however, terrific. There is considerable emphasis on Russian space research, which not only makes clear the great progress made but also the extent to which Soviet engineering has concentrated its efforts in this one field.

TWENTY PAVILIONS

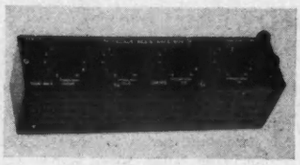
One broad question raised by an exhibition of this kind must be, what do industrial firms get out of it? Some 50 companies are listed in the guide book as having cooperated in the British exhibit. This cooperation ranges from lending some small item of equipment to setting up a complicated working model. The visitor trailing through a selection of the 20 pavilions in the International Labour Exhibition, comes away with very mixed impressions. If, as is very likely, he remembers that it was on the British stand that he saw the model of a jet engine, or of the Girling brakes, then the work put into the pavilion has not been in vain. Clearly this sort of thing must be done well if it is done at all. There have been cases in the past where cheeseparing has led to unfavourable comparisons between Britain's showing and that of others.

Italians, generally, are somewhat cynical about Italia '61, mainly because of its great cost. The Pavilion of Labour alone is said to have cost over £2 million, and was supposed to be designed so that it would be used as a school when the exhibition was over. It will take a very ingenious man to fit a school between the beautiful columns of Nervi's building, and to heat it during the cold Piedmontese winter.

Anyone passing through or near Turin this summer would do well to spend an hour or two visiting Italia '61. Apart from anything else it is worth taking a ride on the monorail and pondering on the reasons why it is apparently not possible to build one out to London Airport.

DECADE RESISTANCE BOX

Development Use



THE Decade Resistance Box Type RD2 is a switched unit covering a range from 1 ohm to 10,000 ohms with four dials. The manufacturers anticipate that its use lies primarily in development laboratories and technical colleges where medium accuracy is required, and where low price, strong construction and convenience are of importance. A 10 ohm to 100 kilohm model is also available.

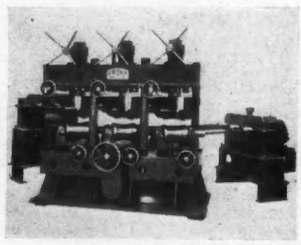
The resistors are non-inductively wire-wound with a copper-nickel alloy, and have been temperature stabilized. The maximum current marking on each decade, 600, 200, 60 and 20 mA, indicates the maximum continuous current permitted, but this value may be exceeded by 50 per cent for short periods. The accuracy of adjustment is stated to be better than 0·2 per cent at 20° C, except for the lowest decade for which it is 1 per cent.

Conventional switches are fitted, these having a minimum contact resistance of less than 6 milli-ohms. They have been selected to give long life, provided that the unit is used with non-reactive circuitry. The instrument is of rigid construction, having a solid mahogany case with a $\frac{3}{16}$ in thick, stove-enamelled front panel. The control knobs have been chosen for ease of manipulation, and they traverse markings of clear, large white figures. An internal aluminium liner is fitted which makes contact with the front panel, and this provides totally enclosed screenings for the switches. The size is 3 in by 3¼ in by 12 in, and the weight 2½ lb.

The unit represents a useful development tool in electronic engineering experimental work, providing, it is claimed, the resistance value required in a particular circuit in a few seconds. It can be used as the variable in a variety of bridge networks up to audio frequencies. *Lionmount and Company Limited, 40 Hatton Garden, London EC1.*

TUBE STRAIGHTENER

Driven Multi-Cross Rolls



ILLUSTRATED here is the "Bronx" multi-cross roll tube straightening machine, Series 6.CR.7, which has recently been introduced. It is capable of handling ferrous and non-ferrous tubes from ⅜ in up to 3½ in diameter.

Features emphasized by the manufacturers are that all the rolls are power driven; no guide bars are required between the rolls (which eliminates marking of the material); the tube is held between three pairs of line contact rolls: and that the rolls themselves can be easily adjusted so that the tube is satisfactorily supported.

The power drive to the rolls is taken from two totally-enclosed gear boxes with vee-belt transmission from two motors; and to allow full adjustment, universal couplings and spindles are fitted between the rolls and the gear drives.

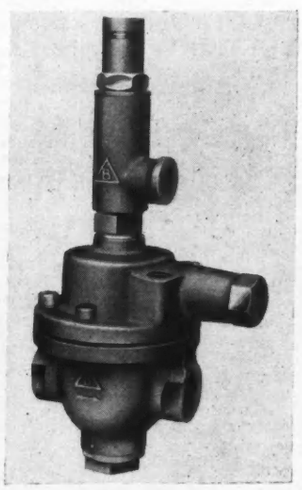
All the three upper rolling elements may be adjusted vertically to suit tube dimensions. In the case of the centre rolls both bottom and top elements can be adjusted vertically to enable the necessary deflection to be applied to the tube. All rolls are provided with angular adjustment in order to facilitate line contact setting.

This machine can also be supplied with single-speed motors to give a fixed straightening speed of 250 ft per minute, or with two- or three-speed motors to give a straightening speed up to 400 ft per minute.

Tube straightening machines of this type are now manufactured to cover a complete range of tubes from 0·020 in up to 12 in in diameter. *Bronx Engineering Company Limited, Lye, Stourbridge, Worcestershire.*

EXCESS PRESSURE PROTECTION VALVE

For Steam Lines



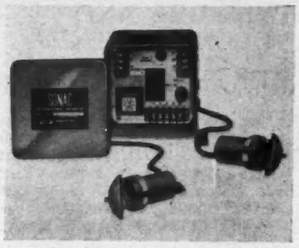
THIS improved protection valve is of particular interest in that the steam supply is not shut off completely in an emergency, the downstream reduced pressure being always maintained at the set level so that process work is not interrupted.

A double-beat valve is attached to a piston across which a pressure differential will be produced by any marked inlet pressure increase. This lifts the piston which brings the main valve closer to its seating faces, and the downstream line is automatically protected. When pressure returns to normal, the valve automatically resumes its original position.

The incorporated relief valve, which lifts at a required safety pressure, deals with minor pressure rises, but severe ones will tend to close the main valve automatically, although maintaining a downstream supply at pre-set reduced pressure. A needle valve adjustment permits performance to be matched to a specific application. This new device, for a line working pressure of 150 lb per sq. in, has screwed ends to fit pipe sizes of ¾, 1, 1¼, 1½ and 2 in. *Sir W. H. Bailey and Company Limited, Albion Works, Patricroft, Manchester.*

SENSING AND SWITCHING SYSTEM

Ultrasonic



USING an ultrasonic sound beam, Sonac, a new sensing and switching system, is expected to have wide application in industry for automatic counting, package routing, level control, positioning and sorting.

The system comprises three major parts: a control unit containing a transistorized amplifier, a plug-in output relay, and a power supply; and two hermetically-sealed acoustic sensors. These matched sensors convert electrical energy to ultrasonic energy and vice versa. One acts as a transmitter, the other as a receiver. Electrical energy from the control unit is converted to ultrasonic energy by one sensor which emits a continuous ultrasonic beam. The second sensor receives the beam and converts the ultrasonic waves to electrical energy which is returned to the control unit.

The equipment is not affected by ambient light, dust, industrial contamination, steam, smoke or vibration, and the beam is imperceptible. The installation will detect solids or liquids, opaque or transparent objects, ferrous or non-ferrous metals, and it is claimed that fast or slow moving objects can be sensed at a wide range of distances. The beam can be made several feet wide or will function through holes down to 0·030 in in diameter.

The manufacturers state that the beams will follow almost any path provided no object is directly in front of them. Units can therefore be remotely located, the beam being conveyed to the work areas with flexible tubing. Units are available for a range of standard mains voltages. *Westool Limited, St. Helen's Auckland, Co. Durham.*

AMPLITUDE ANALYZER

For Noise Analysis

A NEW and compact amplitude distribution analyzer, designated as Model 317, is now announced by Quan-Tech Laboratories, Inc., of Boonton, New Jersey.

This unit establishes the amplitude-probability of random signals, and has applications in the determination of threshold requirements, and in calculating error or false alarm probabilities and similar functions.

A voltage "threshold" level is pre-set by a front panel control; noise levels which exceed the pre-set voltage level are read, or monitored, by a scale calibrated in percentage with reference to time.

The instrument is fully transistorized and operates over a switching rate of up to 5 Mc/s maximum. Amplitude ranges are 100, 10 and 1 per cent full-scale. The accuracy of the instrument is given as ± 3 per cent full-scale reading.

Both normal and inverted operation may be carried out for greater accuracy in reading small percentage values. An output for the purpose of driving a counter is available at a front-panel BNC connector. The size of the unit is 8½ in by 5 in by 6¾ in, and its weight is 5 pounds. *Sylvan Ginsbury Limited, 8 West 40th Street, New York 18, New York.*

PARAFFIN DISPENSER

Coin Operated

DESIGNED for the convenient sale of paraffin, this electrically-operated two-shilling coin slot machine is self-contained and readily installed. It is believed to be the first in the UK.

The unit contains a heavy-gauge metal dispensing tank with an air control valve and an automatic device which closes the coin slot when the machine is empty. A solenoid valve controls flow into the customer's container. Dispensing accuracy is within 2 per cent for one gallon. Other quantities may be delivered by simple adjustment.

Liquid transfer is by a flooded suction pump. A coin selector rejects pieces with unusual characteristics. The cabinet structure is in mild steel with ivory finish, 58 in high by 20½ in wide by 8 in deep. Installation requires connection to a stock tank of sufficient capacity, and operation is from 220/250V 50 c/s supply. Power consumption is 8 W idling, 30 W dispensing and 200 W replenishing. *E. J. Dawes, 6 Union Street, Middlesbrough, Yorkshire.*

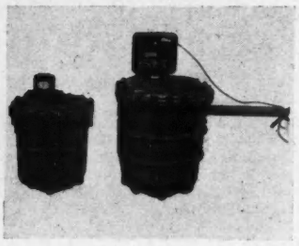
PRESSURE AND VOLUME INDEXES

High Pressure Gas Meters

Now available from Parkinson Cowan Gas Meters are a base pressure index and a base volume index for use with high pressure gas meters. These indexes eliminate the need for the complicated calculations which have been associated in the past with the accurate measurement of gas at high pressures.

High pressure gas is becoming increasingly popular in the UK for a variety of commercial and industrial applications. Special high pressure gas meters were lately introduced to this country by Parkinson Cowan. Following a recent sales agreement with the American Meter Company Incorporated, Parkinson Cowan are now able to market in Great Britain several pieces of ancillary equipment for high pressure meters, including the instruments described here. The illustration shows, on the left, one of the high pressure meters with a normal index, the one on the right being fitted with a base volume index.

Briefly, the base pressure index automatically compensates for the gas pressure by mechanically multiplying the volume of gas by the pressure factor, and it registers the amount of gas at base pressure which has passed through the meter. The base volume index performs an identical task, but in this case provision is also made for temperature compensation.



A supplementary volume and pressure gauge is available for use with both instruments. This gauge plots on a chart the time and pressure at which each thousand cubic feet of gas passes through the meter, thereby providing a permanent record for analysis and reference purposes. *Parkinson Cowan Limited, Dobcross, Oldham, Lancashire.*

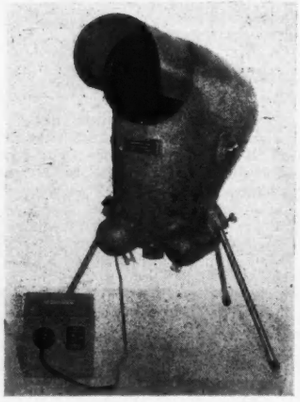
STEREOSCOPIC PROJECTOR

For Small Assembly Work

The Stereoscope stereoscopic projector is a form of projector microscope, its applications being in inspection and small assembly work; it produces a magnified three-dimensional image of components under inspection without the use of glasses, and eliminates the eye fatigue associated with the use of microscope eye-pieces over long periods.

The instrument may be bench or machine mounted and gives magnifications of 7½, 15, 30 and 50 times. The position of the head in viewing the true stereosopic image produced is not critical. Daylight viewing and good depth of focus are further advantages claimed, together with a large field of view—a 1 in diameter circle is available at 7½ times magnification.

This unit is strongly made and has no moving parts. It is supplied complete with 7½ times magnification objective, twin illuminators with lamps, heat filters and tripod for bench mounting. A mains transformer giving 110 V from 200/220 V or 230/250 V is available, with high/low lamp control; spare lamps, hood extension and 15, 30 and 50 times magnification objectives may also be had separately, as may an image inverter for assembly applications and a coaxial illuminating attachment. *Vision Engineering Limited, Send Road, Send, Woking, Surrey.*



TEMPERATURE CONTROLLER

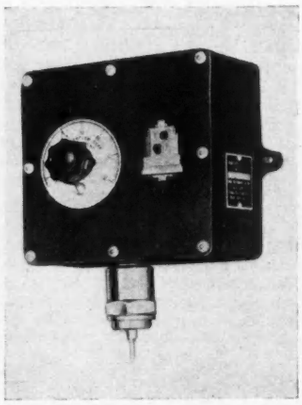
For Cargo Ships

A new type of temperature control instrument which has been designed to keep reefer cargo temperatures at a level constant to within 1½° F is being employed on the cargo refrigeration systems of the recently-launched SS Export Banner. The same type of control instruments are now being contemplated for others of the new American Export Line cargo vessels.

The systems are equipped with Partlow Model GWS controls, which are mercury-actuated instruments for which the manufacturers claim high sensitivity and close temperature control.

GWS controls operate on the principle of expansion and contraction of mercury. A capillary connects the control to a mercury-filled bulb within the refrigerated compartment. Temperature changes in the reefer box are "reported" by transmission through the capillary to the control instrument. A switch is then actuated so as to open or close a valve regulating the flow of coolant.

These weatherproof controls are being used by the Carrier Air Conditioning Company to control the operation of the refrigeration systems it is supplying and similar Partlow instruments are being used on new Moore-McCormack Lines cargo ships now in service or under construction. *Ad. Auriema-Europe, S.A., 172A Rue Brogniez, Brussels 7, Belgium.*



POWER DRILLS

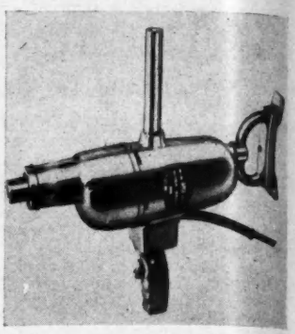
Two-Speed

Now being introduced is a range of two-speed power drills of Peugeot design. The range, which has a large power reserve, is doubly insulated and fully earthed to ensure safety in operation.

Radio and TV suppressors are incorporated. With a gearbox giving two speeds, these power tools are able to operate on all types of materials and at the same time give a comparatively long drill-bit life.

From the commencement of design, the universal ac/dc motor unit has been considered as a power force for the driving of a complete range of portable and bench-mounted drills. The range covers sizes from ¼ in to 1¼ in, the P322 1¼ in capacity unit, for example, having a low speed of 156 rpm when running on load, and a high speed of 280 rpm on load.

The nett weight of this unit is only 22 lb, which is said to make it the lightest and most compact unit available. The PF23, shown here, has a wood capacity of 1·28 in, that for steel being 0·92 in.



The light weight of the units reduces operator fatigue, and also presents more uses for the drill; it is therefore particularly suitable for site work. It has been possible to combine the low weight construction with properties of unusual resistance to stress and usage. Together with these power drills a full range of tools in this Peugeot design is now available. *Melbro Machine Tools Limited, 2A Alexandra Road, Manchester 15.*

UNIVERSAL MILLING MACHINE

With Automatic Version

Shown at the Budapest Industrial Fair which opened on 19 May this year was the MU 250 universal milling machine illustrated.

This unit is fitted with a 250 mm by 1,000 mm table, and its frame and guides give a rigidity which allows the best use to be made of the 2·8 kW motor.

The 18 speeds available from the main spindle, which has both right and left-hand motions, are selected with a single lever. The speed range covers 17 variations, and speed is controlled from a panel mounted on the front of the bracket.

Feed controls are also operated from the front panel, and quick feed motions are controlled through separate push-buttons which maintain the motion as long as they are held in a pressed-down position.

This machine can also be ordered in the form of a cycle equipment; this version allows the setting of the table for the carrying-out of automatic cycles. With this variant of the machine, specially designed stops permit change-over from quick motion to working feeds, and also enable control of motion in the reverse direction. These controls also provide for automatic starting and stopping of the spindle, as required by the job in hand. *Hungaropress, Budapest V. Hold U. 17*

ELECTRONIC VOLTMETER

Mirror-Backed Scale

This new voltmeter, Model 317, manufactured by Ballantine Laboratories, is designed to measure from 300 microvolts to 300 volts at frequencies from 10 c/s to 11 Mc. It is useful as a null detector from 5 c/s to 30 Mc.

As a calibrated amplifier, it provides a stable gain up to 60 db with a frequency response of ± 1 db from 6 c/s to 11 Mc. The indicating meter has a 5 in mirror-backed scale to make full use of the precision features of the instrument. Voltage scales of 1 to 3 and 3 to 10, each with 10 per cent overlap, are located in a position adjacent to the mirror scale.

A scale graduated from 0 to 10 db provides a ready reference for measurements in db.

Input impedance with probe is 10 megohms shunted by 5 pF; without probe it is 2 megohms shunted by 11 to 24 pF, depending on range. Indication is average-responding, calibrated in rms of sinewave. Power supply is at 70 watts, 115/230 V, 50 to 400 c/s; the unit is available either in portable or in rack versions. *Sylvan Ginsbury Limited, 8 West 40th Street, New York 18, NY.*

THE USSR INDUSTRIAL EXHIBITION

Earls Court, London, 7 — 29 July 1961

THIS exhibition of Soviet industry and culture, the largest which the USSR has yet held outside its own frontiers, attracted wide interest in the many fields covered.

Described on this page are some of the Russian developments in engineering and industrial technology which were represented on this notable occasion.

On the closing of the exhibition it was estimated that business done had exceeded £18 m, and that there had been 600,000 visitors.

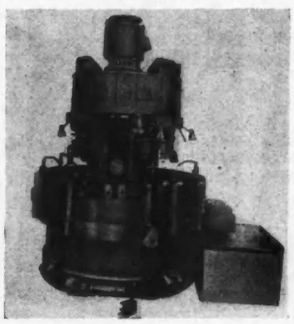
CORE-BLOWING UNIT

MODEL 305 is designed for semi-automatic production of small-size cores by blowing a sand mixture of varying raw strength into vertically- or horizontally-split core boxes, using compressed air. The machine is simple in design and all parts and units are accessible for servicing and adjustment. Automatic pneumatic control of output is from a command apparatus located in the pedestal, from which it can be withdrawn for adjustment.

The core-blowing reservoir is equipped with interchangeable nozzles (sand-blowing and sand-blasting) which increase the field of application and promote efficient forcing of core-sand mixture. A mechanism for adjusting the clearance between core-box and nozzle is provided, this allowing the use of core-boxes of different heights. Output is quoted at 360 cores per hour, maximum dimensions of core-boxes being 280 by 280 by 300 mm, and maximum core weight 7 kg. *V/O Stankoimport, Moscow G-200.*

8-SPINDLE INDEXING LATHE

For Chucked Blanks



DESIGNATED as model 1283, this semi-automatic vertical 8-spindle indexing lathe is designed for both rough turning and finishing of chucked blanks in mass production quantities. The machine can work independently or it can be built into an automatic production line.

Blanks are usually machined simultaneously at seven working stations by means of slides designed according to the operations to be performed. Each station can be set up for various operations independently.

In operation, each slide can be switched to a slow feed, to rapid traversing or may be stopped, according to the command received from the punched card for that station. The workpiece is clamped hydraulically, and the lock pin of the machine is located at a large radius which contributes to the high accuracy claimed for the indexing of the rotary table.

The machine can be supplied with an automatic loading device, a chip removing device, and other attachments which extend its capabilities. As compared to the former model in the series, this new machine has a widened range of spindle speeds—from 32 to 287 to 50 to 800 rpm; the traverse of the slides is increased from 200 to 350 mm and the power of the main drive motor from 40 to 100 kW. The number of spindle operating speeds is 35, and slide traverse covers 350 mm. Nett weight is 19,500 kg. *V/O Stankoimport, Moscow G-200.*

CORN HARVESTING COMBINE

Welded Design

COMBINE KKX-3 is intended for harvesting corn, in the wax stage and fully ripe, and for cob-picking and stalk-cutting.

The frame is of welded design, supported on two pneumatic running wheels. The cutter bar is placed in front of the frame on a square pipe and consists of a knife, ledger plates and a crankpitman mechanism.

The cob elevators are mounted between the cob pick-up mechanisms at an angle of 40°. Movement of cobs is by metal scrapers mounted on a bushing-roller chain. Mounted under the cutter head is the cut mass elevator, the cut mass being carried along by a scraper transporter. A hand-actuated hydraulic lift serves to control adjustment of the cutting height and the shifting of the combine from the transport position to the working position, and back. Operation is with a T-54 tractor, and the working units are driven from the power take-off. *V/O Avtoexport, 32/34 Smolenskaya Pl, Moscow G-200.*

GRAIN DRILL

Tractor-Mounted

MODEL 16 is designed for drill-sowing cereal crop seeds.

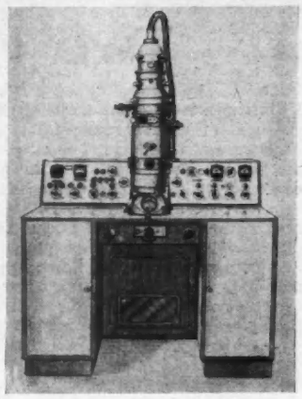
The frame is made up of a main beam of square pipe cross-section and a coulter beam of angle bar, joined to each other by brackets; also a hitch for mounting on the tractor, together with supporting-driving wheel mounting frames.

Coulter working depth is regulated by a screw arrangement. The feeding device is shaft-driven from the supporting wheel through a gear-chain transmission. The metal seed-box has stamped spool-type sowing units. Seed feeding-rate is regulated by changing the size of the feeding holes.

The coulters are of the double-disc type with disc covers, arranged in two rows along the run of the drill with inter-rows of 270 mm. The seed pipes are spiral-shaped strips, and the markers are of the disc type, interlocked and controlled by the tractor driver. This driver-operated drill is mounted on T-24 and T-28 tractors. *V/O Avtoexport, 32/34 Smolenskaya Pl, Moscow G-200.*

ELECTROSTATIC MICROSCOPE

High Resolution



THE high resolving type M5 electron microscope is designed for observation and photography of images of specimens with light and dark fields. It may also be used for the micro-diffraction study of separate portions of the specimens within 1 to 2 μ, and for stereoscopic photography of specimens.

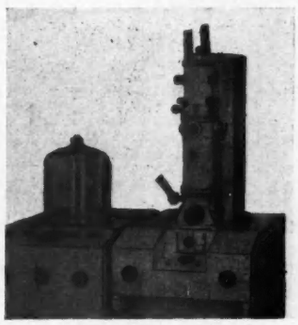
An electromagnetic four-lens system gives a magnified image of the specimen on a fluorescent screen or photographic plate. The condenser lens reduces from 2·5 : 1, and with only one lens this provides a diameter of area lit by electrons of 10 to 8 μ. The objective lens has a stigmator.

For obtaining two diffraction patterns for comparison, the design of the camera provides for the possibility of separate exposures of the two halves of the photographic plate. Image focusing is by an optical binocular microscope with a magnification of × 8·5. The electron gun has an adjustable negative bias and an armoured high-voltage lead-in.

For preparing specimens for observation, the set includes a vacuum system. In this, the high output of an oil vapour pump (200 l/sec) makes it possible to create the operating vacuum within four or five minutes. The semi-automatic vacuum switch facilitates control of the microscope. *V/O Stankoimport, Moscow G-200.*

ELECTRONOGRAPH

Small Size and Low Weight



THE Type 40 is a small-size electrostatic electron microscope of simplified design. It is used for investigating various specimens in transmitted rays as well as for obtaining stereoscopic images. When the lens unit is removed, the instrument may be used as an electronograph (electron diffraction camera).

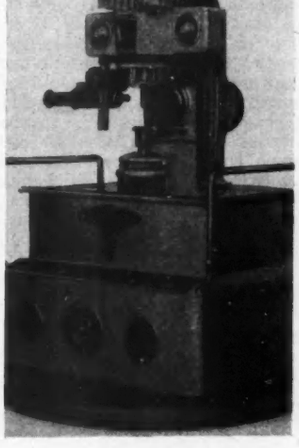
This equipment is designed in the form of two individual units. One of these comprises the microscope's column, feeding device and control panel, and the other incorporates a vacuum system together with a thermal spray installation and a spot welding attachment. The vacuum system unit may be supplied separately for use as an installation for specimen preparation.

Acceleration voltage is given as 40 to 50 kV and the resolving power is specified at 50°A. Magnification covering four stages is from × 1,500 to × 10,000. The objective tilt angle obtained in stereophotography is 4°, the maximum angle of diffraction being 8°. Working vacuum level is 5×10^{-4} mm Hg and the time taken to evacuate to this level is from 15 to 20 minutes. Five specimens may be carried in the microscope; the size of photographic plates is 4·5 by 6 cm and ten such plates can be accommodated by the machine.

Specimen grid (diaphragm) diameter is 3 mm, and power consumption is put at 1 kW. The microscope's overall dimensions are 95 by 75 by 140 cm and its nett weight is 200 kg. *V/O Stankoimport, Moscow G-200.*

ULTRASONIC DRILLING MACHINE

For Diamond Holes



THIS semi-automatic ultrasonic table machine, type 3M, is designed for machining diamond die holes. Holes of any desired form can also be made in hard alloys, minerals, ceramics and some brittle materials. Depending on diamond hardness and hole size, machining takes two to four hours.

A table with hand-operated shift facilitates the approach of the diamond to the instrument. A magnetostriction regulator assembly moves at 10 mm/sec, and a pointing mechanism considerably increases productivity and diamond-hole quality. An optical device for controlling the instrument's pointing and inspection of diamond holes is included.

The machine is provided with an ultrasonic two-stage self-energizing generator. An automatic time regulator is fitted to control working movements. There are two measuring instruments in the head: one serves for indication of diamond pressing stress and the other for control of instrument vibration during machining. *V/O Stankoimport, Moscow G-200.*

Two Way Pendulum

With the completion of the large accelerators now under construction in Europe, America and the Soviet Union, it is likely that the present art will have reached the end of its development. To attain higher particle energies —in the range between 30 and 100 GeV—entirely new methods will have to be used in order to prevent a further rise in accelerator costs. That it is necessary to reach higher energies—preferably accompanied by a high beam intensity—can be readily justified on scientific grounds. But it is essential to accomplish the extension with the greatest economy of means.

Three Years of Fermentation

At the 1956 CERN symposium on high energy physics a number of new ideas were suggested which offered the possibility of cost containment. These ideas were either radical extensions to present accelerator principles, or entirely new departures. In addition to plasma accelerators, (ENGNG., vol. 188, p. 510), colliding beams, beam stacking, and stochastic acceleration methods were proposed. During the years following the first symposium the practicability of these new concepts was explored in the high energy laboratories of the world, and the results reported at the second CERN symposium held in September, 1959.

Put Chaos Into Order

The justification for seeking higher energy particle beams is intimately linked with the need

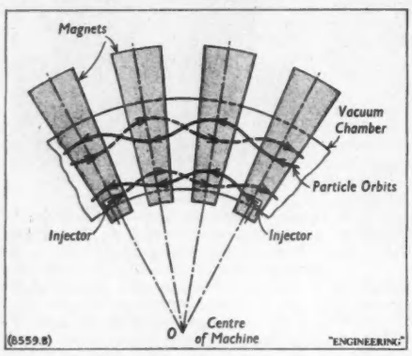


Fig. 1 Two-way radial sector accelerator stacks and stores two oppositely circulating beams of protons which are allowed to collide to produce high-energy interactions.

for higher particle intensities. W. K. H. Panofsky of Stanford University spoke of the need to re-examine the present classification of unstable subatomic particles. With higher energy interaction, a number of new particles might be produced that could put order into the large selection that has been found so far. (Atomic Review, 9 Oct. '59, 19 Aug. '60.) But with high energy interactions the lifetime of a particle may be so short that the transition from a real particle to a virtual particle becomes continous and unrecognisable. In addition, starting from a higher energy, the number of possible channels of interactions through which the initial energy is dissipated increases greatly. In order to make a statistically significant survey of all possible interactions and sequencies of interactions a large number of events must be studied, hence high intensity is an essential feature of higher energy accelerators.

Spiral Ridge

At present the most refined form of the proton synchrotron is the fixed-field alternating-gradient accelerator in which the focusing of the particle beam is accomplished by reversing the magnetic gradient of the machine in successive magnet sectors. The advantage of fixed-field accelerators is that particles with fairly wide variation in momenta can be accommodated at the same time. As a result of this flexibility very high beam intensities can be obtained since the loss of the less energetic particles from the beam is reduced. A further extension to this principle called the spiral sector machine—is being tried in various research establishments, including CERN and the Midwestern Universities Research Association (MURA). By constructing the field magnets in spiral instead of straight radial sections the size of the magnets can be reduced for the same maximum energy.

Collision Course

Conventional particle accelerators, proton synchrotrons in particular, rapidly increase in cost with increasing energy because the size of the magnet ring is a function of energy. As the tolerances on the physical dimensions of the magnet are already quite critical, any increase in diameter would add to the cost through additional refinements in construction, quite apart from the cost of more magnet steel. An obvious method of increasing the energy involved in an interaction between the particle beam and the target (without increasing the diameter of the magnet ring) is to use for the target a second beam of charged particles circulating in the opposite direction.

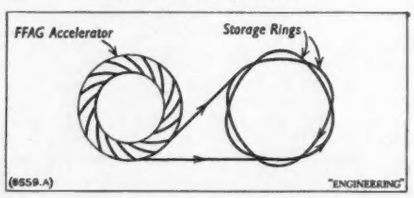
Accent on Intensity

The difficulty with colliding beam techniques is that the density of the target is reduced when compared to fixed metal-foil or similar targets, and hence the probability of an interaction diminishes. To make such a machine useful, the intensity of the two beams must be increased. A method suggested in 1956 was to accumulate the particles from several pulses of the accelerator, and use them in one big burst. The technique, christened " beam stacking," can be used to improve the performance of colliding beam accelerators. Three different approaches are now under study. In Russia the research group under A. A. Kolomenskij is experimenting with a single two-way radial-sector fixed-field machine in which two opposite beams are accelerated, stored, and stacked; and interaction is brought about by passing both beams out of the accelerator simultaneously on a collision course. The arrangement of the Russian proposal is shown in Fig. 1. Similar work is done at CERN and MURA.

Stacking and Storing

From America come two proposals for using specialized machines. At MURA a spiral ridge accelerator would be used to inject fully accelerated particles into two superimposed

Fig. 2 Separate magnet rings may be provided to accelerate protons and to store the two counter-rotating beams.



storage " rings," as shown in Fig. 2. The rings have a tri-lobe shape which provide a number of intersection points along the particle paths. L. W. Jones of MURA compared the magnet diameter of a 10 GeV two-way accelerator designed for storage—124 metres—and an alternate arrangement using a spiral ridge accelerator and two storage rings, each of which requires a 50 metre magnet ring. But the choice between the two designs is not a matter of simple economics. The storage ring pair has a more favourable geometry and probably has a higher current density than a two-way accelerator, but beam transfer from the rings is more complex and the machine is less flexible.

Pieces of Eight

A third alternative is being tried by the Princeton-Stanford group for colliding electron beam experiments. The schematic arrangement of the machine under construction at Stanford is shown in Fig. 3. A 500 MeV linear accelerator is used to inject a series of pulses into each of two interlocking storage rings shaped like a figure eight. A straight-line experimental track is provided at the point of tangency of the two rings. Vertical steering magnets placed near the experimental track are used to bring the beams into collision under a large array of detectors. As with most colliding beam experiments, the

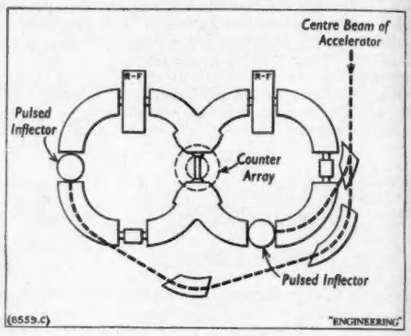


Fig. 3 A figure-of-eight arrangement is being tried at Stanford University.

beams will cross at a small angle, forming a diamond-shaped source of interactions which only approximates the ideal point source.

Random Voltage Variation

Stochastic accelerators were first proposed by Burshtein, Veksler and Kolomenskij of Russia in 1955. In the usual design of accelerators the accelerating voltage is programmed in a cyclic manner, producing definite pulses of accelerated particles. As the name implies, in a stochastic accelerator the variation in the accelerating voltage is random. Particles are injected continuously into the accelerator, the operation of which is based on the assumption that the accelerating voltage will be " right " for a finite number of injected particles at any moment. There is thus a definite probability that a certain number of particles will be continuously accelerated. The maximum attainable energy is clearly based on the survival rate of the particles: theoretically a particle of any desired energy could be produced in a sufficiently long time. Both Kolomenskij and Lebedev of Russia, and R. Keller of CERN reported on progress with this type of accelerator. The feasibility of stochastic acceleration was demonstrated at CERN with a 5 MeV machine in 1958. Stochastic machines can produce continuous beams with intensities comparable to fixed frequency cyclotrons and synchrocyclotrons, and are in certain respects cheaper to construct, but the technical difficulties in the radio-frequency equipment have not yet been overcome for applications above 50 MeV.

Reactor Notes

Investigation for Berlin: Two United States and one German firm have been requested by Berliner Kraft und Licht (BEWAG) AG to make a closed cycle water reactor study for a 151 MW station for the city.

Increased Power: The heavy water cooled and moderated reactor which has been operating for the past three years at the Massachusetts Institute of Technology at 1 MW(t) is now being modified to operate at 2 MW(t).

Companies

Changing Pattern in Courtauld Profits

GROUP profits from trading and investments for COURTAULDS last year were £18,696,544. In the year before they had been at the record level of £21 million. Now Sir John Hanbury-Williams, the Courtaulds chairman, reports that in the first three months of this financial year, group profits are down on those of April, May and June of last year, which were the best three months of the year.

Some improvement is expected in the last nine months of the year, though the general uncertainty in the economic position only increases the difficulty of maintaining the profit level.

Total turnover of the group increased last year but lower profits in a number of sectors were only partly counterbalanced by improvements in others. In North America the group's fibre activities had a difficult year. In the United Kingdom credit restrictions held back the profitability of industrial paint sales for motor cars and domestic appliances.

A quick look at the sources of the total Courtauld trading profit shows how almost the whole of the downturn in the group's fortunes has come in textiles—in the non-textile activities there has in fact been an improvement, lifting non-textile profits close behind those of the textile side.

Source of Group Trading Profit

	1958/59 £m	1959/60 £m	1960/61 £m
Textiles	5·4	10·5	6·6
Raw materials	2·3	3·2	3·1
Non-textile activities	3·1	4·3	5·3

Two new chemical plants are being built at Spondon and another has been completed at Trafford Park, Manchester. BRITISH CELLOPHANE continues to expand. Non-textile sales of acetate and viscose products have been considerably stepped up and the investment has been increased for sulphur and cellulose derivatives and petrochemicals.

In the research departments 50 per cent more strength has been given to viscose tyre yarns and further advances are in development. The most recent improvements mean that the tyre manufacturers will be able to build more flexible tyres at lower cost for specialized uses.

New Home for Finance House

The Astley Industrial Trust Limited, who provide a complete range of finance facilities covering everything from heavy industrial plant to domestic appliances are now operating through their subsidiary company, the Astley Leasing Company, a system which is popular in the United States and Canada whereby industrial plant may be obtained without capital expenditure.

A lease agreement has advantages over a conventional hire purchase in as much as there is no mandatory time limit on the agreement although Astley impose a limit of 10 years. No deposit is required, the lessee receiving the equipment for the first instalment of the monthly rental which normally decreases over the second half of the period and on which he is able to claim tax relief. At the termination of the agreement the lessee of course surrenders the equipment although he may in certain circumstances be offered an option to purchase. However, as most plant users budget on a set "life" for each item of equipment, it seems most probable that it will be expected to have fulfilled its usefulness when this time arrives.

Speaking of the finance as a whole Colonel Sir Stanley Bell, chairman of the group who introduced Lord Rootes before the opening of new premises in Notting Hill Gate last month, said that it was common knowledge that difficult times were being faced and stressed the need to change the emphasis from consumer spending to the more urgent task of re-equipping and lowering of costs. In these undertakings the finance concerns could play an ever-increasing role.

Sir Stanley started the group in 1935 for the purpose of providing finance facilities for the motor industry. Since then steady progress has been maintained, and assets now stand at £30,000,000. Substantial interests are held by the District Bank Limited, Manchester, and the Pearl Assurance Company Limited.

Upward Sales and Downward Profits

Dearer and tighter credit plus the discontinuance of the scheme for supporting the building societies in financing the buying of older property can be expected to slow up some of the building industry's activity and therefore its demands for fittings and equipment.

ALLIED IRONFOUNDERS Limited have the greater part of their products going into the building industry; they are also one of those companies who in the past year have contrived to absorb rising production and distribution costs within their price system. The result has been a slip in the group trading profit from £3,005,081 in the year before to £2,829,425 last year. At the same time the depreciation charge has risen from £468,265 to £604,788, a reflection of the spending on new plant and buildings, a substantial part of which was not due in production until the fresh financial year.

Including the mechanized plant for bath production at Falkirk, Scotland, and the large press being installed in the Leisure kitchen equipment factory, the group expenditure on modernization and development in the year up to 1 April of this year was £1,300,000.

Allied Ironfounders have substantial interests in South Africa, where their factories at Durban and Newcastle were fully employed throughout the year. Some fall in sales took place in the two months prior to the chairman's review. Mr. G. S. Steven, the chairman, visited the Union earlier this year and gained the impression that the standard of living of the native population was rising. They were seeking increasingly expensive appliances, including electric cookers, of which Allied Ironfounders are the largest manufacturers in South Africa.

Back at home, the sales of the group in the past financial year moved upwards significantly, with rising production and distribution costs cutting into profit margins. More recently it has been necessary to meet this position with some price rises.

Growing interest in central heating has led to the formation of the Aga Heating Division. The whole solid fuel appliance industry has benefited from the National Coal Board's marketing policies. Sales of Aga solid fuel boilers have shown a useful increase

Mobile Showroom for Plessey Products

A new mobile showroom which will be used by the PLESSEY GROUP of companies as a travelling exhibition and sales promotion vehicle has started it first journey on behalf of PLESSEY NUCLEONICS Limited. Touring British atomic power stations and manufacturers with nucleonic interests, it is displaying the Company's latest developments including neutron detectors, pulse-height analysers, general purpose contamination monitors, milk monitors and health physics instruments for Civil Defence and other applications.

The unit (*inset*) is fully equipped for continental travel, and is to be used on overseas tours to stimulate exports in addition to making sales promotional journeys in Britain. The interior is specially designed for flexibility so that the items on display can be readily changed to feature any of the diverse activities of The Plessey Group.

Among the new products on show for the first time on this initial trip are selective gamma monitor, a neutro-gamma monitor, a contamination monitor, an ionisation chamber and a range of boron-lined proportional counters.

Prosperous Position of Ruston Associates

Provided that the proposed pay-roll tax and further national wage increases do not price them out of the export markets RUSTON & HORNSBY, says the chairman in his annual review, should hold their position and next year find an improvement in the group's affairs.

The first half of the condition has so far been avoided. Mr. Lloyd's operations of last week left out the half-expected pay-roll tax imposition. The result of his exhortation to pause in income improvements for a while, which will decide the second half of the Ruston chairman's qualification, has some months in which to emerge. There is as good as no possibility of claims being withheld. Whether engineering firms, Ruston and Hornsby among them, have to struggle on in the export market under the crippling burden of even higher production cost is dependent on the outcome of the battle.

Despite an output maintained at the level of the previous year, the Ruston trading profit has fallen, due to narrowing profit margins. Taxation has not declined in proportion as the result of a drop in capital allowances and to the increase in the exaction of Profits Tax. Net profit for the group for the year was £491,119, a fall of £134,589 from the result of the previous year.

On top of the cost inflation, underemployment of capacity, made worse by shortage of labour, contributed to the final result.

A general improvement in trade has been taking place and is continuing. Orders received by Ruston and Hornsby during the year have increased and the order book of the company and its subsidiaries now looks better than a year ago.

An important R & H subsidiary is DAVEY, PAXMAN and Company, of Colchester, who have a slightly complicated position. Due partly to non-recurrent items, the subsidiary, with a lower output than in the previous year, returns a higher profit. Davey, Paxman now have a better order book, and the under-employment of capacity should disappear later in the year, but, for reasons already indicated, the current year may show a reduction on last year. The following year should reflect the busier working conditions approaching.

A general improvement in industrial and marine business included an order for the propulsion and auxiliary machinery for two large ferries being built in British Columbia. These will be the largest horse power marine propulsion installations produced by the group. The boiler and chemical plant side has been active, with orders keeping pace with products leaving the works.

Two of the brightest spots are the associates RUSTON-BUCYRUS and RUSTON AND HORNSBY (INDIA). The first has had to use extensive overtime working and available sub-contract capacity to the full to meet a fast growing order book.

The Indian associate lifted its output of horizontal engines to record levels. The capacity is to be expanded to manufacture air-cooled engines and further to include a range of small vertical water-cooled engines.

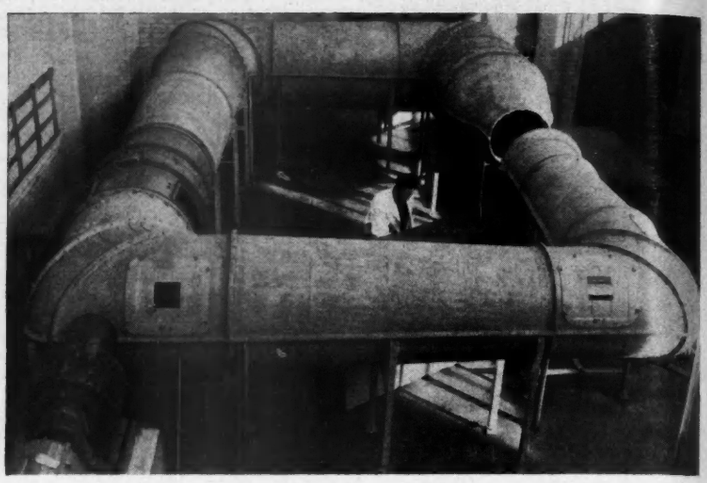
Glass Reinforced Epoxy Wind Tunnel

A closed-circuit open jet wind tunnel recently installed in Hatfield Technical College was made from glass reinforced epoxy by Stanboro' Pattern and Model Makers Company. Epophen resins were supplied by Leicester Lovell.

The idea of using this material instead of wood or metal came from discussions with Stanboro' Patterns. Leicester Lovell say that the cost of a one-off circular wind tunnel like this one compares favourably with that of a wooden structure of similar size and design. Because the formers can be used repeatedly, subsequent ones would be less expensive.

The tunnel is nearly 80 ft long with a maximum diameter of 4 ft. The plastic walls were built up on semicircular wooden formers and the resultant halves were bolted together with ¼ in BSF nuts and bolts. The circumferential joints were sealed with ¼ in diameter rubber in a groove preformed in the flanged surface, and the longitudinal joints were sealed with a plastic sealing strip.

Removable inspection hatches 18 in square are incorporated with a 6 in square window of Perspex acrylic sheet. The corner vanes are made from 16 swg aluminium sheet. The tunnel is bonded with chopped glass fibre and epoxy resin to a 2 in by 2 in by ¼ in angle-iron frame fitted with anti-vibration rubber cushion feet. The fan unit is driven by a 20 hp motor.



This wind tunnel is said to have a very smooth inner surface and to be dimensionally stable. It is made in glass reinforced epoxy resin as an alternative to to wood or metal.

Leicester Lovell claim that the surface finish obtained on the resin could only be matched in, say, wood by time-consuming preparation and special finishing techniques. Tolerances of ± 0·031 in were specified on all dimensions and the finished moulding is claimed to be stable in varying atmospheric conditions and temperatures. Also, it is light in weight.

Leicester Lovell and Company Limited, North Baddesley, Southampton.

Alloy Steel for High Temperature Use

Samuel Fox and Company have started commercial production of an alloy steel for service temperatures up to 675° C. It is known as Esshete 1250. It is a 15Cr-10Ni-6Mn-steel with small amounts of silicon, molybdenum, vanadium, niobium and boron.

From five years testing and research, the makers conclude that it has a high level of rupture strength with adequate ductility, good weldability, structural stability and oxidation resistance at elevated temperatures for long periods. They say it also has good manipulation properties and is thus admirably suited for service in power stations of advanced design.

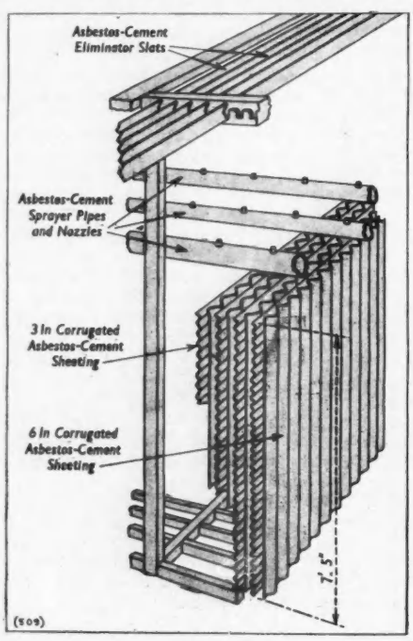
Esshete 1250 has "proved satisfactory" in bars, tubes, pipes and large forgings; sheet trials are in progress. Large bars, pipes and plates can be readily fabricated in either the hot or cold condition (i.e. not exceeding 650° C, or not less than 900° C, respectively) but a re-solution treatment within the range 1,050 to 1,150° C will be needed. In this condition, mechanical properties range from an ultimate tensile strength of 39·0 tons per sq. in, with elongation on $4\sqrt{A}$ of 67·0 per cent and are duction of area of 69·6 per cent at room temperature, to corresponding figures of 23·0 tons per sq. in, 40·0 per cent and 51·2 per cent at 700° C. Proof stress at 0·1 per cent elongation for room temperature and 700° C are 13·8 and 8·1 tons per sq. in, respectively.

Stress-to-rupture tests have covered a period of 25,000 hours to date and indicate that the stress-to-rupture at 675° C in 10,000 hours is 10·4 tons per sq. in. The stress which produces 0·1 per cent creep strain under the same conditions is 4·70 tons per sq. in.

The low proof stress values quoted earlier can be improved by warm working to 32 tons per sq. in at room temperature with an elongation of about 48 per cent. There is also considerable improvement in the high temperature proof stress after warm working; when considered in conjunction with the improved creep properties, this makes the steel well suited in this condition for use as high temperature bolting material, say the makers.

Samuel Fox and Company Limited, Sheffield 10.

Asbestos-Cement Cooling Towers for Power Station



Two cooling towers at the Padiham B generating station are packed with asbestos-cement sheets developed for this purpose by Universal Asbestos Cement Manufacturing Company. They were designed by L. G. Mouchel and Partners and built by Mitchell Construction Company. The two towers are 300 ft high and have a diameter at pond cill level of 190 ft. Each tower handles 3½ million gallons of cooling water per hour and produces a temperature drop of about 18° F.

Commenting on this development, UAM say that even in the early days when power station cooling towers were timber framed and boarded structures, asbestos-cement was used for the pipework, distributing branches and spray nozzles. Its reliability became proved over a number of years. They then tried using the material for packing. One of the first uses was in a small tower at Leicester power station which was repacked in 1945 with corrugated sheets of the material secured by bronze bolts and spacers. The corrugations were all in one plane.

In conjunction with consultants specializing in cooling tower work, UAM then evolved what they describe as a simple and efficient type of cooling pack which needs no spacers or other fixings. The construction can be appreciated from the illustration. In this pack, 6 in corrugated sheets with the corrugations running vertically are interleaved with 3 in corrugated sheets with the corrugations running horizontally. The multiple points of contact are claimed to give considerable strength so that the sheets are somewhat thinner than the normal roofing grade.

In the Padiham towers, precast reinforced concrete columns and bearer beams are used to support the packs. The sheets were delivered in bulk and stacked in the catchment pond below before being hoisted to the bottom part of the tower ready for making up into packs. UAM say that as the result of detailed planning, six fixers packed over 100 tons a week and site breakages were less than anticipated, only one sheet in every 400. At one stage the fixers packed over 140 tons in one week.

At the perimeter of the tower is a ring of radial sheets, but the remainder are set in a series of rectangular packs and carry the spray pipes, which are fitted on small precast bearers. The spray pipes are fitted with a series of distributor heads spaced at about 2 ft 6 in centres. Above them, asbestos cement eliminator slats, made from single 6 in corrugations, are fitted into a series of splayed castellations on the side faces of the upper beams. These eliminators perform the very necessary function of preventing small water droplets from being carried up and out of the tower, comment UAM. They therefore keep water losses to a minimum.

Universal Asbestos Manufacturing Company Limited, Tolpits, Watford, Hertfordshire.

Electrolytic De-Ruster Salts

Canning are now offering a product for electrolytically de-rusting iron and steels which they claim is a vast improvement on alkaline de-rusting materials previously available. They say that the solution (No. 3218) is speedy in action and removes light films of rust in a matter of seconds and heavy rust encrustations in 3 to 5 minutes.

The makers comment that electrolytic de-ruster salts provide an alternative to acid pickling processes and have a wide application, especially for treatment of components with critical dimensions, since the action is confined to the rust and there is no attack on the basic steel.

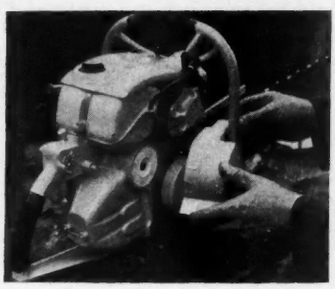
The normal procedure is to make the articles cathodic in a water solution of the chemical used in plain welded steel tanks (equipped with fume extraction when operating in a confined space). Current density should be 50 to 100 amp per sq. ft at 4 to 6 volts. Mild steel plates are used as anodes and the solution is operated at a temperature of 180 to 200° F.

If both heavy rust and black oxide scale have to be removed, the current is reversed to make the articles anodic in the circuit. This latter treatment is also useful, say Canning, for the de-rusting and de-scaling of high tensile steels where hydrogen embrittlement must be avoided.

W. Canning and Company Limited, Great Hampton Street, Birmingham 18.

Chain Saw Has Plastic Cover

This illustration shows a glass reinforced polyester clutch housing being placed in position on a Danarm direct-drive chain saw. Osma Plastics, who undertook the matched-die moulding of this component, report that the material is now standard for the housing on this model. They



also comment that the use of glass reinforced plastic gives improved protection from corrosion and mechanical damage from flying wood chips.

Prototypes of this saw have also been fitted with engine cowlings made from the material.

Osma Plastics Limited, 551 London Road, Isleworth, Middlesex.

High Temperature Grease Proved in Service

A grease which contains molybdenum disulphide is now being sold by Rocol. It is called Molytherm and is recommended by the makers for continuous service above 350° F. It is claimed to withstand long periods above 450° F and short periods up to 550° F, such as were previously lubricated only by silicones.

The grease is based on a high flash point oil with a thickener, and is said to be soft enough to be applied through grease cups or nipples. It is resistant to steam and water and shows considerable resistance to the stripping action of solvents and vapours. Where power is sufficient to overcome the higher drag, Molytherm can be used as a cog or gear grease at all temperatures down to 35° F.

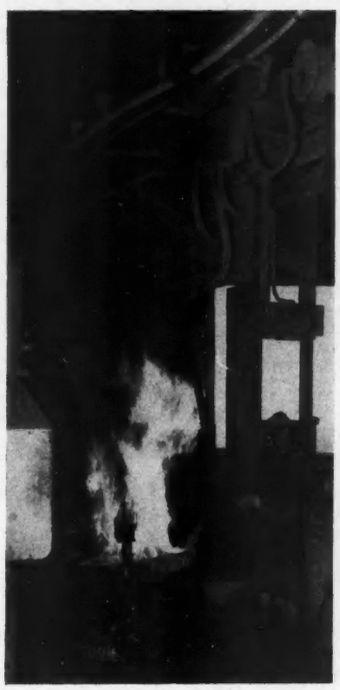
Rocol have recorded several uses which have become established during the last 12 months of development. For instance, on furnace loading rollers in temperatures up to 480° F it is reported to have given good performance during a 2 month test. For undefined fan bearings of 2¾ in od running at 900 rpm the following log was made: " bearings ok after 192 hours. They were stripped, regreased and ran 960 hours, with servicing at 400 hours. After next stripping, they ran 270 hours but stopped at 500° F. They are now running satisfactorily at 420° F."

Rocol Limited, Swillington, Nr. Leeds.

Bus-Bar Casing is Phenolic Extrusion

An overhead power distribution system which is made safe with an extruded plastic casing has recently been installed at the Avonmouth works of National Smelting Company. The system was produced by Clayton Safeguard of Liverpool and is used for supplying electrical power to the overhead travelling hoist gear at the works. It is said to be one of the few types available in which the bus-bars are enclosed in an insulating material.

The rigid casing for the bus-bars, which can be seen in this illustration, is made from Rockite phenolic plastic extrusion supplied by British Resin Products. This company comments that a phenolic extrusion was used in preference to other plastics because it is unaffected by heat, thus permitting the system to be used over fur-



naces, and for handling crucibles. The production of the curved lengths used in the Clayton Safeguard system is regarded by British Resin Products as being a notable technical achievement.

British Resin Products Limited, Devonshire House, Piccadilly, London W1.

Resin Impregnation of Asbestos-Cement

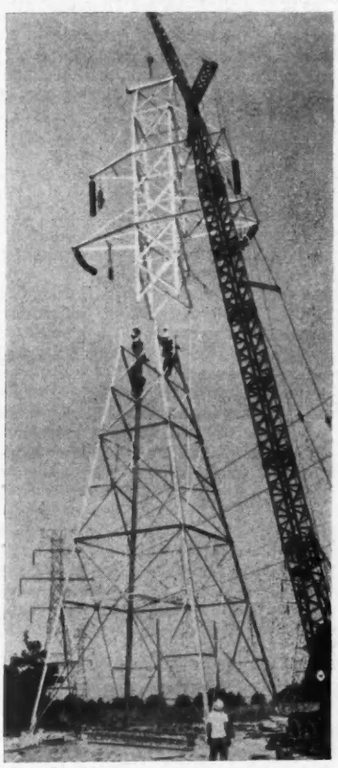
Midland Silicones have recently developed a silicone resin suitable for impregnating asbestos-cement board such as is used in electrical gear. They claim that impregnated material will retain good electrical insulating properties for very long periods even in conditions of 100 per cent relative humidity, whereas under similar conditions untreated board will soon show a serious loss of insulation resistance. The resin has the number DP2728.

Among the users of equipment incorporating components of silicone-impregnated asbestos-cement is the Steel Company of Wales. At the company's Abbey Works this type of board forms individual mountings for the 440 volt dc contactors on the soaking pit charging cranes. Steel Company of Wales comment that the mountings operate in ambient temperatures up to 90° C for prolonged periods in an atmosphere containing conducting dust: their records show that this material has proved trouble-free.

Midland Silicones Limited, 68 Knightsbridge, London SW1.

Electricity Pylons Use Aluminium Extrusions

In America, two hundred electricity pylons have been constructed with the top part made from aluminium extrusions. The illustration shows one of these being lowered on to the galvanized steel lower section for a double-circuit 115,000 volt line. Niagara Mohawk Power Corporation chose this composite design because industrial fume contamination of the Niagara Falls area atmosphere necessitates frequent painting of steel structures and because they anticipate maintenance savings, report Aluminum Com-



pany of America, who supplied and fabricated the aluminium extrusions. The towers are of five various designs and range in height from 77 to 133 ft. The heaviest aluminium section for one of them is said to be 2,950 lb and the lightest lb.

Alcoa say they have estimated costs to show that the higher first cost of the aluminium structure sections will be amortised within 14 years, taking into account initial installation savings and two maintenance paintings. Bases for the towers were fabricated by the American Bridge Division of US Steel Corporation, and it is reported by Alcoa that this company performed a test in September, 1960, to verify the adequacy of the aluminium-steel composite structure.

Aluminium Company of America, 1501 Alcoa Building, Pittsburg 19, Pa., USA.

The Constructive Use of Explosives

The controlled use of explosives is finding new fields in production for compacting, forming and testing. In this article an assessment is made of the scope of their present and probable future development.

By H. Thomas, B.Sc., Ph.D.

Nobel Division, Imperial Chemical Industries Ltd.

THERE is much current interest in the use of small quantities of detonating explosives to produce local and controlled effects in metal-explosive systems. Many of these special applications of detonating explosives are not new, but changing technical requirements in the engineering and metallurgical industries have aroused interest in their likely development.

A brief account of the properties and characteristics of solid detonating explosives must be given for a technical appreciation of these applications. The process of detonation is characterised by the passage of an intense shock wave which leaves in its wake gaseous products at high pressure and temperature. As the detonation wave moves through and towards the unreacted surface of explosive its intensity is sustained by the chemical decomposition of that explosive and the release of quantities of energy.

The rate of passage of the wave and thus the rate of detonation is virtually independent of the shape or size of the explosive and of the surrounding pressure, though it can differ markedly from one explosive to another. Each explosive has, however, a critical diameter below which detonation cannot readily be sustained. The hydrodynamic theory of detonation provides a physical understanding of the detonation process and an account of this theory as applied to condensed explosives was the subject of a previous article in this journal.[1]

The velocity of detonation and the power are measurable properties which determine the effectiveness of the explosive in metal-explosive systems. The intensity of the shock wave is a function of the velocity of detonation, while the power is a measure of the useful work which the explosive can perform. The explosives designer can vary these parameters over a wide range, the velocity of detonation of detonating explosives covering the range from 2,000 metres per sec to 8,000 metres per sec. The explosive power can be varied from 25 per cent to rather more than 100 per cent of that of the most powerful commercial explosive, blasting gelatine. These factors show that the explosive forms an important parameter in a metal-explosive system, and one which within limits may be significantly adjusted to meet specific problems.

Hardening of Manganese Steel

Austenitic manganese steel has now been established for many years as a material of construction for heavy duty equipment. The steel, as usually supplied, has a hardness in the range of 200-250 Brinell Number, and this hardness may be increased by shot-peening or by actual impact applied to the equipment during its service life. Such treatment, however, only affects a thin layer of hardened steel.

It has been found[2] that increased surface hardness, together with hardness in depth may be obtained by means of explosives. This may be attributed to the intense shock wave associated with detonation, and experiment shows that an explosive with a high velocity of detonation is required for hardening manganese steel.

In the explosives technique a layer of explosive, $\frac{1}{8}$ in thick, is placed and secured on the surface area to be hardened, and then detonated. The technique may be varied in that successive charges may be so detonated, or the thickness and weight of explosive for any given charge may be increased. The results depend to some extent on the detailed explosive treatment applied to the metal. It has, however, been clearly established that such explosive treatment may increase the surface hardness to greater than 400 Brinell Number, while a significant increase in hardness, say greater than 300 Brinell Number, may be achieved at depths of $\frac{1}{2}$ in or more below the surface of the metal.

This hardening of the metal is attributed to the molecular reorientation of the steel resulting from the high pressures associated with shock waves generated by the explosive charge. A plastic explosive based on pentaerythritol tetranitrate and having a velocity of detonation in the range of 6,500 to 7,500 metres per sec has now been developed for this application. The explosive is commercially available under the trade name "Metabel," and is supplied in the form of a sheet $\frac{1}{4}$ in thick, which may be readily cut into any desired shape.

The increased hardness of the manganese steel is, of course, accompanied by a corresponding increase in the yield strength and tensile strength. Prehardening of manganese steel equipment will therefore usefully increase its service life, and thereby reduce the operating costs for such equipment. The performance of explosively hardened manganese steel as compared with untreated material for any particular application may depend on several factors and may only be assessed by field trial. The results of such field trials will establish the particular applications of manganese steel where it will be desirable both technically and economically to preharden the equipment by explosives before service use. This application is attracting attention in the UK and an account of one such development has recently been reported.[3]

Compacting of Metal Powders

The application of detonating explosives to the compacting of metal powders has been reviewed recently.[4] A few years ago[5] an explosive technique was developed for compacting metal powders. Aluminium, copper, iron, and titanium powders were compacted to a density approaching the theoretical value. The compacts were produced initially in the form of cylinders of circular cross-section, and also as cylinders with hexagonal or fluted cross-section. Compacts of up to $4\frac{1}{2}$ in diameter and 20 in length have been produced, but the practical limit of size has not been established.

The experimental technique consists of surrounding a suitable container with an explosive charge such as Cordtex detonating fuse. The metal powder to be compacted is placed in the container, and the whole assembly immersed in water. The metal powder is compacted on firing the explosive charge. This technique is still only in its development stage, and much experimental work is required in order to correlate the physical and metallurgical properties of the compacted powder with the experimental conditions. Recently the technique has been modified so as to permit the compacting of powders into annular cylinders,[6] while certain non-metallic powders have also been compacted by explosives. Thus graphite has been compacted by explosive techniques into the form of an annular cylinder of density 2·15 gm/cc. Mixtures of aluminium and graphite and also aluminium and titanium have been explosively compacted in which the composition of the mixture has been altered from one component to another in graduated steps along the length of an annular cylinder.

This technique may be useful in special cases where existing mechanical techniques are not readily applicable. Potential applications of the method are now being explored.

Sheet Metal Forming

The increasing use of high tensile strength metal and alloys such as titanium, the nimonic series of alloys, Fortiweld, and certain stainless steels has introduced new problems in sheet metal forming. Existing mechanical presses are not adequate to meet the new requirements, and consequently there is some scope for new sheet metal forming techniques. It is in this context that sheet metal forming by explosives has attracted attention both in this country and the USA. The subject was discussed at a group session of the National Conference organized by the Institution of Production Engineers in October, 1960, on Modern Trends in the Manipulation of Metals,[7] from which it is evident that several firms in this country are taking an active interest in this development.

In the simplest case the sheet metal blank is placed in position over a female die, and provision should be made for evacuating the entrapped air between the die and the metal blank. This assembly is immersed in water and an explosive charge placed in position at a suitable stand-off distance from the metal blank On firing the explosive charge, the high pressures generated force the sheet metal blank to take up the shape of the die.

The experimental arrangement may be readily modified to permit other sheet forming operations, such as forming a desired contour from a blank in the form of a truncated cone. Cordtex detonating fuse has provided a convenient means of supplying the necessary explosive charge, but explosives in sheet or pelleted form may also be used in these applications.

A cursory consideration of the process indicates that it is not a competitor of established methods of metal forming in cases where these techniques are satisfactory. Explosives do not provide a cheap source of energy and the technique is not suitable for high speed production. Sheet metal forming by explosives may, however, find useful application in special problems. Certain metals and alloys are not readily formed by existing mechanical presses into the shapes frequently required by design engineers, and new forming methods are necessary for such cases. Explosive forming may be regarded as one of the alternative techniques which is available for development. Within this specialized field of application, explosive forming may well provide the design engineer with more scope and flexibility.

Many factors contribute to the use of explosives in sheet metal forming. The properties of the explosive and its orientation relative to the blank, the shock wave characteristics of the system, the material of the die, the behaviour of the metal under high strain rates and their effect on the metallurgical properties of the metal are all of importance.

So far most of this experimental work has been approached on an empirical basis, but it is clear that there is also scope for a more fundamental investigation. A useful working knowledge of the relevant factors is now being accumulated, and the indications are that sheet metal forming by explosives may provide a useful special tool for the fabrications engineer. The technique requires only one die, so that it offers savings in capital costs which may be considerable when relatively few formed parts are required.

Applications of Shaped Charges

The use of shaped or hollow explosive charges to produce a uni-directional shock wave has been known for many years; the principle involved is frequently referred to as the Munroe or Neumann Effect. The assembled shaped

Concluding: The Constructive Use of Explosives

charge comprises a priming charge, and a main explosive charge in which is placed an inverted metal cone. On firing such a shaped charge the resulting shock wave is uni-directional and intensified, but limited to a small effective area of application. For effective operation the main charge must necessarily be an explosive of high velocity of detonation, and its priming system and metal cone must be carefully designed. Consequently, such special charges are expensive, and an earlier review[8] concluded that this has limited its prospects for commercial applications. Shaped charges initially found military use for demolition work and as anti-tank weapons.

Following field trial and experimental work, suitable shaped charges have been developed for tapping open-hearth furnaces, and this technique is now in use in the UK. Typical shaped charges (which must be suitably insulated against heat) for this application have been described in patent literature[9] and are now commercially available. Important advantages claimed for their use are the removal of personnel from the vicinity of the tap-hole when the hot metal begins to flow. The time required to tap the furnace is reduced and this permits better control of the furnace operation.

In overseas countries shaped charges are also successfully used for oil well perforation. Miscellaneous applications of shaped charges include the cutting of heavy gauge metal plates and submarine cables. The embossing of complex designs on metal plates is of technical interest only but presents a unique example of the effects the controlled use of explosives.

Metal Testing by Explosives

Several metal-explosive systems have been devised for testing blasting explosives, and such systems may also be developed for testing metals. The name of Pellini[10] has become associated with a test in which explosives are used for examining the impact properties of metal and alloys. In this test a 14 in square plate of the heavy gauge metal under test is placed on a robust metal die, in which there is a circular opening. An explosive charge in the form of a thick circular disc is supported at a convenient height above the metal under test. On firing the explosive charge the metal under test is bulged or cracked. The test piece may then be examined in detail. The test may be carried out over a range of metal temperatures, and provides a means of assessing the effect of crack defects in the test specimen.

Conclusions

Special detonating explosives have been devised for hardening manganese steel and tapping open-hearth furnaces, while explosives already commercially available are frequently suitable for sheet metal forming and powder compacting.

The potential use of detonating explosives in these metal working industries introduces new problems but adequate safety precautions can be taken to permit their use in routine operations.

There is an adequate background of explosives technology to permit further development in this field, when it is considered that such techniques may be used with technical advantage.

References

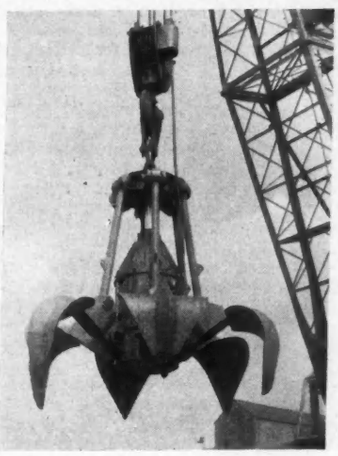
[1] Paterson, S. ENGINEERING, vol. 163, (1947) p. 98.
[2] U.K. Patent 765,305.
[3] Smith, G. F. *Quarry Manager's Journal*, vol. 44, (November 1960) p. 439,
[4] Montgomery, W. T., and Thomas, H. *Powder Metallurgy*, no. 6, (1960) p. 125.
[5] U.K. Patent 833,673.
[6] U.K. Patent Application No. 8498/60.
[7] Hollis, W. S. The Institution of Production Engineers, National Conference, Brighton, October 1960.
[8] Davidson, S. H., and Westwater, R. *Mine and Quarry Engineering*, vol. 15, (May 1949) p. 140,
[9] U.K. Patents 656,587 and 658,625.
[10] Pellini, W. S. *et al. Welding Research*, vol 31, (1952) pp. 561 and 596.

Orange Peel Grab Handles Scrap

Handling steel scrap and similar material is a difficult operation with a crane fitted with an ordinary grab, since the irregular shape of the load prevents the grab from handling to full capacity. An "orange peel" type of grab, shown in the illustration, appears to have overcome much of this difficulty. Introduced from Germany, it has been fitted to a Rapier 1520 mobile crane and is believed to be the first of its kind in this country.

The grab is an 8·8 cu. ft electro-hydraulic model with a fluid tank incorporated in its frame and a vertical hydraulic pump operating the cylinder above it. Power is supplied by the crane generator at 250 volts and the motor has a rating of 3 kW giving a closing time of 6·5 seconds.

The Rapier 1520 to which the grab has been fitted is designed for factory and scrap yard use, cargo handling, and railway and heavy haulage work. Its maximum prop loads are 15¾ tons with a 13 ft propping base or 17¼ tons with a 10 ft propping base; the maximum wheel loads with an eight ton load are 10 tons on one steered wheel and 7½ tons on one driven wheel. A wide range of strut and cantilever jibs is available.



The "orange peel" grab of German design and patent attached to a Rapier 1520 mobile crane.

It seems that the combination of crane and grab form a very efficient unit for the handling of heavy and irregularly shaped materials.

Newton, Chambers and Company Limited, Thorncliffe, Sheffield.

Rubber De-Bonding Development

A four cubic feet capacity de-bonding plant installed recently for the Empire Rubber Company is a development of earlier types. It works on the principle of destructive distillation in a closed vessel, like previous plants, but special attention has been directed to preventing fouling of the vapour pipes.

A double ended 1 hp motor which drives the air blower also drives a pump which circulates distillate oil throughout the system. This irrigates the offtake piping, washes the rubber vapour in a scrubber cooler and maintains a constant level in a seal tank.

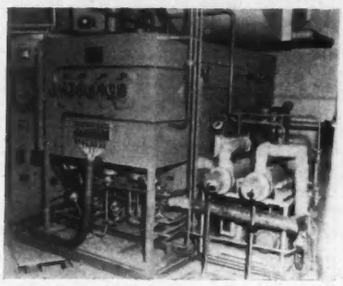
The plant is compact, easily installed, and incorporates the accurate temperature control that is necessary when handling aluminium and other easily distorted metals. A small bore low pressure steam supply enables the retort to be emptied while hot so that operating times and fuel costs are reduced.

Operating times vary with the rubber content of the items to be de-bonded but a load of rubber blocks measuring 2 in by 3 in by 1 in and bonded to mild steel brackets and studs can be treated in 4½ hours from cold, and a second charge while the setting is still hot in 3¼ hours.

W. C. Holmes and Company Limited, Turnbridge, Huddersfield.

Helium Purification in Japan

The Japan Atomic Energy Research Institute has recently begun to operate helium purification plant built by Hitachi Limited. This equipment is designed to remove traces of air entrained with helium which is sealed in the heavy-water reactor core tank. Air enters the system when the fuel elements are changed, and must be removed. A purifier of the circulating type extracts the air from the helium, as it is continuously removed



The Hitachi helium purifier plant.

from the tank, and subsequently returns the highly purified gas to the tank.

Available data on the plant include:

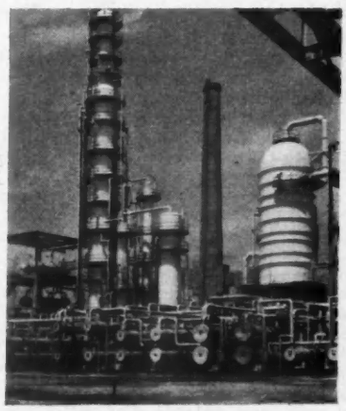
(*a*)	Overall gas input	20,000 litres (90 per cent helium, 10 per cent air)
(*b*)	Discharge rate	0-100 litres/minute
(*c*)	Purification value	Better than 99 per cent helium.

This helium purifier is the first of its type to be produced in Japan and is the subject of several patent applications.

Japan's New Refinery

The Mitsubishi Oil Company's second oil refinery, built and equipped by the Chiyoda Chemical Engineering and Construction Company, of Tokyo, became operational in May of this year. It occupies an area of about 327 acres and is situated at Mizushima in the Okayama Prefecture. Initial performance figures include:

(*a*)	Crude oil pickling ..	40,000 barrels/day
(*b*)	Atmospheric (high pressure) crude oil distillation	40,000 barrels/day
(*c*)	Vacuum crude oil distillation	20,000 barrels/day
(*d*)	Merox plant	2,000 barrels/day



Part of the plant of the Mitsubishi Oil Company's second oil refinery.

On the Shelf

By Frank H. Smith

DSIR in their handout of the highlights of *Building Research 1960* (HMSO 7*s*) quote the Building Research Board: " We believe that an immediate important step forward in the technical efficiency of most building firms would be the allocation to one senior member of their staff of the duty of keeping up-to-date with technical matters." From inquiries reaching the (Building Research) Station daily, it is quite clear that " neither the professions nor the contractors make anything like full use of the information available." That, brother, is not peculiar to the building industry, but I would suggest that instead of that senior member of the staff they employ a librarian.

Exactly three hundred years ago, John Evelyn presented his tract *Fumifugium: or the Inconvenience of the Aer and Snoake of London Dissipated* to King Charles II. To celebrate this nice round figure, the National Society for Clean Air (Fumus fugetur) of Field House, Breams Buildings, London EC4, has reprinted the tract at 5*s* in cloth and 2*s* 6*d* as a paper back. Get rid of the noise and the fug and life might be worthwhile again.

From the D.S.I.R. comes an announcement of another of these cover-to-cover jobs which a research association undertakes with the benevolent godparentage of the Department. The Rubber and Plastics Research Association undertakes the translation of *Plasticheskie Massy* into *Soviet Plastics*, and if you want further information, go to Rubber and Plastics Age, Gaywood House, Great Peter Street, London SW1. This brings the DSIR translation total to 17.

Dated June is City and Guilds of London Institute (76 Portland Place, London W1) *New and Revised Schemes for the Session* 1961-2. There is an amendment, for instance, to the Technical Illustration requirements; an examination of comparatively recent introduction, I believe. Their Form 4 lists subjects in which they will hold examinations in the coming year, outlines the conditions and describes the Institute's aims. Railway Carriage and Wagon Construction has been dropped and Radiation Safety Practice will be introduced. Straws show . . . or do I mean *autre temps, autre moeurs*?

I was a little puzzled at receiving from Faber and Faber (24 Russell Square, London WC1) a publication *Proposed Studies on the Implications of Peaceful Space Activities for Human Affairs* by Donald N. Michael and seven collaborators, for, when I opened the cover of this 7*s* 6*d* paperback, I found that inside was an ordinary USGPO publication such as is always put out in the case of reports to the US Senate. I have crowds of them dealing with the space programme of NASA and have always bought them through HMSO. Is anybody poaching? Another curious point is that Faber's fix a publication date of 27 June. The USGPO date is 24 March. The matter is not made any simpler by the legend on the spine which gives two names—Michael (already mentioned) and Brookings, which is the name of the Institution that prepared the report for NASA. All very confusing.

As you know, I am a great believer in the old " all work and no play " stuff and it is always a pleasure to let you know about your hobbies (and as I write thus I imagine myself *vis-à-vis* my typical reader, whom I will describe one day). *Engineering Journal* for June (the Canadian journal) has a good article on " An Evaluation of Plywoods and Plastics in Boat Construction."

Should any of you weekend sailors think of trying something a bit more ambitious, the St. Lawrence Seaway Authority have issued a revised *St. Lawrence Seaway Masters' Handbook* (Queen's Printer, Ottawa) at $2. A copy must be on board each vessel transiting (their word) the Seaway. You have been warned.

Roads by Pythagoras

The Geometric Design of Modern Highways. By JOHN HUGH JONES. *Spon.* (63*s*)

Professor J. H. Jones was for twelve years on the research staff of the Institution of Transportation and Traffic Engineering at the University of California and has acted as a consultant in several important highway design schemes in the USA.

His book is a slim volume of 240 pages and eight chapters. The geometrical problems of modern highway design are covered in chapters 2 to 4 which deal with the road itself, horizontal and vertical alignments, cross falls and other surface features, sign posts and other road " furniture," and so on. Chapters 5 to 7 then deal with road junctions. This is all useful material for the engineer with main highways in this country to design, particularly as the diagrams of junctions suit our traffic direction. This part of the book then is a valuable summary of American practice for the British engineer. Chapter 8 gives examples with good photographs of many well-known motorways in the USA both in general terms and in detail; there is a single example of European design, the " trumpet " interchange at Ridderkerk in Holland.

Chapter 1 of Professor Jones's book enters a more controversial field: here he deals with the general problem of arriving at the network of main roads that will best meet the needs of the community it serves. The procedure is to estimate the number of traffic lanes needed by guessing what the traffic on a proposed new road will be like, in volume and composition, over the next thirty years. Allowances are made for the growth of the community and for traffic being attracted to the new road from outside. He assumes that the engineer will have a great deal of data at his command and will have the trained staff and facilities to obtain more.

The problem in the USA is relatively simple; car owning is within the reach of all classes of the community and their statistics show that all their needs for transport have been met by about six vehicles for every ten members of the community. This includes goods vehicles and public-service vehicles as well as private cars. This figure of six vehicles for every ten people is a kind of saturation value the USA reached several years ago. In Great Britain we have about two vehicles for every ten people, but for some years now our rate of increase has been running at 7 or 8 per cent per year. In other words, we are about a third of the way along their path but coming up fast. If present trends continue, traffic on our roads will be doubled by the mid seventies, and trebled by the late eighties or early nineties. An engineer in Great Britain planning for the future and trying to project his mind over the next thirty years has an unenviable task since he should really plan for treble the present traffic.

In the political field also the road planners in the USA have an easier task than their opposite numbers over here. In the USA it is taken for granted that adequate highways are a necessity and President Kennedy has lately proposed that some 40,000 miles of new six or eight lane highways shall be built at a cost of some £15,000 million. In comparison the schemes of new construction in Great Britain are not impressive; here the motor car is regarded traditionally as the plaything of the rich and the target for penal taxation. Here, too, there has been very little road design or construction since the late thirties so that we are faced with the problem of training a whole generation of road engineers. This book should play a useful part in this task; that it deals with American conditions is no drawback since the USA at present leads in this field. When a second edition of this book is called for Professor Jones could usefully tidy up the English in places and add a bibliography; two publications not mentioned and bearing on his field are Newmann's *Der neuzeitliche Strassenbau* (4th ed., 1959), and the Road Research Laboratory's Technical Paper No. 48, " The Assessment of Priority for Road Improvements " (1960).

T. LONSDALE.

Oscillations, Linear and Nonlinear

An Introduction to the Theory of Vibrating Systems. By W. G. BICKLEY and A. TALBOT. *Oxford University Press.* (30*s*)

Contributions to the Theory of Nonlinear Oscillations. Volume 5. Edited by L. CESARI, J. LASALLE and S. LEFSCHETZ. *Princeton University Press, Princeton, New Jersey; Oxford University Press, London.* (40*s*)

In 1581 Galileo (timing the swings of a chandelier in Pisa cathedral) discovered the isochronism of a simple pendulum, and thus probably initiated the scientific study of oscillating systems. Since then a lot of work has been done on these systems—and a great many books, both large and small, have been written about the subject.

The book by W. G. Bickley and A. Talbot on the theory of vibrating systems belongs to the second category. In its 238 pages (which also contain two appendices, 175 exercises, answers, a short bibliography, and an alphabetical index) the subject is presented in sixteen chapters. Taken chapterwise, 15/16 of the book is concerned with linear oscillations; only in the final 1/16 are some nonlinearities discussed.

The theory of systems with one degree of freedom is covered by the first five chapters—the topics include fundamental properties of vibrating systems, kinetic and potential energy, determination of natural frequencies, dissipation of energy and damping, steady state, and transients.

The chapter following is devoted to Lagrange's equations—and thus is preparatory to studies of more complicated systems. Numbers of more complicated systems, both discrete and continuous, follow in the course of the nine final " linear " chapters. In addition, these chapters include topics such as Rayleigh's principle, electro-mechanical analogies, wave propagation, sound, and approximate methods for continuous systems. In the final chapter of the book some aspects of nonlinear systems are discussed. An example on a simple pendulum (without the usual stipulation of " small " swings) is used to illustrate the dependence of frequency on the amplitude. Van der Pol's equation, characterising oscillations in certain electrical circuits, is used to explain a graphical method of solution. The chapter is concluded with a brief section on a slowly varying amplitude and phase.

The subject is treated more from the viewpoint of a mathematician than from that of an engineer or physicist. This in itself is not particularly surprising—A. G. Bickley is Emeritus Professor of Mathematics and A. Talbot a Lecturer in Mathematics at London University. This emphasis on the purely theoretical aspects of vibration, however, is quite deliberate. The authors believe that failure and inefficiency, in science and technology, are far more often caused by inadequate understanding of theory and principle than by practical engineering difficulties (!).

The book is primarily intended to acquaint a wide variety of students of engineering, physics and applied mathematics, with the fundamental ideas, principles and results of the theory of vibrating systems. The reader is assumed to be familiar with partial differentiation, determinants, linear differential equations with constant coefficients, differential operators, and series. It has, however, been thought necessary to devote Appendix II of the book to the elementary properties of complex numbers.

The purpose of Appendix I, titled Simple Spring System, is also a little puzzling. It is concerned

with the derivation of the equation of motion for the system—one cannot but wonder why an example has been made of this system by leaving it outside—especially when an item such as Elements of Beam Theory (purely static considerations of loading, shear and bending) is included in the main line of argument.

In general, one gets an impression that perhaps too wide a coverage of the subject has been attempted in the more than somewhat limited space—and in consequence some clarity and consistency of presentation, so essential to a good textbook, has been lost. Some of the symbols used in the book are not very often met with, and the addition of a symbols list in front of the text would decidedly be helpful.

A large proportion of physical systems (oscillating and otherwise) can only be adequately described mathematically by means of nonlinear differential equations; unlike linear differential equations, no general method of solution exists and each case of nonlinearity has to be considered on its own particular merits. The systematic developments of the theory of nonlinear oscillations is relatively new: it was started in the Soviet Union in " the thirties," and is associated with Mandelstam, Papalexy, Ardronov, Vitt, and others. In the United States attention was directed to this field of mathematics somewhat later (N. Minorsky's book on nonlinear mechanics was published in 1947), but in the recent times, and probably because of their close connection with the theory of automatic control systems, nonlinear oscillations have been subject of intensive study.

The present *Contributions to the Theory of Nonlinear Oscillation* is the fifth in the series published by the Annals of Mathematics Studies. The volume (286 litho-printed near-quarto pages) comprises thirteen papers, on a variety of subjects, by a total of fourteen contributors. Here it will be possible to mention only a few.

The volume begins with a paper by J. P. LaSalle on the time optimal control problem. It concerns a control system, defined as one which, at all times utilising all the available power of a limited source, reaches a desired state in minimum time. The paper includes a number of examples illustrating the concepts introduced, and gives applications of the theory developed.

The paper is followed by a work by J. Jarnik and J. Kurzweil on a generalised differential equation depending on a parameter. This forms a continuation of a series of papers on the subject by Kurzweil.

Various types of nonlinear stability problems are investigated by A. Stokes, making use of a fixed point theorem; while a contribution by J. André and P. Seibert deals with the local theory of piecewise continuous differential equations.

The rest of the papers are by J. Cronin, J. K. Hale (two papers), L. Cesari, L. Markus, G. Reeb (written in French), P. Mendelson, C. Coleman and R. P. de Figueiredo—and are concerned with such items as existence theorems of periodic solutions, quadratic differential equations, topological degree, and asymptotic stability.

A variety of styles and a large number of different mathematical symbols have been used, but this is inevitable in a work of this nature.

The volume is provided with an extensive bibliography in the form of references after each paper, supplying a useful background to the present investigations.

The subject is treated at the most advanced level, and with a high degree of specialisation; for a full appreciation and understanding of this volume the reader should be an expert on the theory of nonlinear oscillations (and be able to read French).

But although of no direct use to a vast majority of engineers, physicists and mathematicians, the volume should be regarded as representative of an important and necessary step towards better understanding of nonlinear oscillating systems.

W. U. SIRK

Aerials Large and Small

The Antenna. By L. THOUREL. *Chapman and Hall.* (70s)

Aerial design and construction is an art, in the sense that an art is a science with more than seven variables, and the ideal aerial designer is not only a radio engineer, but also physicist, mathematician and mechanical engineer. In many cases, Jodrell Bank for example, the mechanical aspects are all important, while the radio design could hardly be simpler. No one man, it is safe to say, can now attend to all facets of the largest modern aerials for radar or radio astronomy: certainly there is no one book which will guide him in all aspects of the design.

Even if we confine ourselves to the electrical design of aerials, there are few good books available in English, and these are becoming dated, having generally sprung from the vast aerial development of the Second World War. One is therefore well disposed (despite its grandiloquent and un-English title) to a new book which, the publishers hope, will fill a regrettable gap in the literature. The author's preface explains that the original was written to fill an even more glaring gap in the French literature and that the book is " a review of modern antenna techniques . . . for engineers and technicians." Although highly specialized or very new techniques are specifically excluded, the author claims that the *modus operandi* of any aerial can be deduced, even if it is not explicitly covered. Complicated mathematics " have been reduced to the minimum necessary for understanding," and special attention has been paid to high-frequency aerials, " especially in view of their application to radar."

Such is the intent: how far has it been fulfilled? Certainly the book covers far more ground than any previous work in English. In one volume, we have here more material than in both the Cambridge radio monographs (by R. A. Smith and by Fry and Goward), or roughly as much, but in less detail, as in both the American texts by Kraus and by Silver, on which the present book leans heavily for its references, and, in places, even for its material. Because of this wide coverage, the book is of interest to the specialist only in a few places: there is perhaps the fullest description available in a book of the design of double curvature reflectors, by which is meant here a reflector to produce a shaped beam from a single feed. There is also an interesting discussion on the tolerances allowable in a parabolic reflector which results in two criteria, both far more severe than the rule of thumb tolerance of one sixteenth of a wavelength.

Nevertheless the book should properly be judged by its value to the non-specialist English reader. Such a reader should beware of judging the importance of an aerial by the space it occupies here, and of the translation of technical terms. The " aperture " of a beam is its " beamwidth " in English; the book explains that a " cosecant bearing diagram " and an " effective area radar diagram " are identical, but is not very clear on what they are. The average English technician, one suspects, will find his mathematical apparatus somewhat strained by the necessary minimum of mathematics: he would probably prefer less mathematics and more practical detail of the size, frequency and bandwidth of the aerials described. He will find a short appendix on transmission line theory to be especially good on broadband matching, but that the indexes are rather short and scrappy. In short, he will be confirmed in insular superiority: were he a Frenchman, the original of this book might well be the best available to him. As things are, he is probably still better off with the Cambridge monographs, first published 15 years ago.

M. J. B. SCANLAN

A New Market for Engineering Enterprise

The Economic Development of Libya. *Published for the International Bank for Reconstruction and Development by John Hopkins Press, Baltimore; Oxford University Press, London.* (60*s*)

British exporters in general, and engineering, contracting, and capital equipment firms in particular, should find this report on the Kingdom of Libya's economic potentialities of exceptional interest.

The report, prepared by an international team of thirteen World Bank specialists of several nationalities, including experts on public health, irrigation, tourism, education, agriculture, mineralogy, transport and public utilities, and two economists, is authoritative, painstaking, and exhaustive. It also has, from a businessman's point of view, the inestimable advantage of being clearly laid out, written in good plain English, and thoroughly indexed. Its chapters analyse the characteristics of Libya's economy, foreign aid and economic development, the impact of the oil discoveries, the organization of the Government, and provide detailed individual surveys of water resources, agriculture, livestock and forestry, industry, handicrafts, and fisheries, the tourist trade, electric power, transport and communications, ports and coastal shipping, civil aviation, education, public health, and general financial policies and problems—all full of practical information to industrialists, bankers, traders, and businessmen.

With a population of only 1,200,000, occupying an area of 413,000 square miles (about twice the size of France), Libya belongs to the sterling area, buys 25 per cent of its imports from, and sells 15 per cent of its exports to, the United Kingdom, and receives a grant, which has averaged £3,800,000 since 1954, from the UK in support of its budget. Oil has been discovered and large sums are being spent by no fewer than 16 international companies. Commercial production will start within two years. Oil may enable Libya to be self-supporting within the foreseeable future, and will have a " multiplier " effect in stimulating demand and creating jobs in industries and trades—particularly in construction, transport, and the hotel trade—which can cater for the needs of the companies and their employees.

The report observes in diplomatic language that, if for lack of trained personnel, the Libyan Government as yet hardly attains the highest levels of efficiency, it makes up for this by its " apparent determination " to rely mainly on private capital and initiative to develop industry, trade, and agriculture. The report reasonably suggests that the Government's inexperience in economic affairs is in itself a strong argument for continuing its present policy of leaving as much as possible to private enterprise.

The report says that the Government's most urgent task is to build up its administrative

machinery. Investment in people through better education, medical services, nutrition, and housing, will be more rewarding, though also more difficult, than spectacular public works. The rate at which the economy grows will be powerfully affected by the supply of skilled professional and technical personnel. The public investment programme should be tailored to the talent available. The report concedes that there are disadvantages to Libya in having to depend heavily on foreign engineers and administrators, but points out that if a faster rate of development is desired, extensive use will have to be made of them. For example, demand for building is certain to remain high, and the amount of work done will depend on how fast the capacity of the building and civil engineering industries can be expanded by importing foreign managerial talent, technical skill, and capital.

One of the report's main conclusions is that the exploitation of oil, and the development of industry, will not create enough jobs to employ more than a fraction of the 200,000 people at present engaged in agriculture, but that this shortage of employment will not prevent villagers from continuing to drift to the towns in search of better-paid industrial work, or prevent industrial wages from rising. This movement may lead to growing unemployment and to social discontent. The report therefore emphasises the need to improve the lot of the rural workers. Reform of land tenure, and the promotion of modern methods in agriculture, forestry, irrigation, and fisheries should have high priority.

With the expected development of the oil industry, and the continuing expenditure by the United States and Great Britain on NATO bases in Libya, the prospects for the future justify sober optimism and should induce British industrialists and business men to expand their already substantial share of Libya's exports and imports.

Among likely prospects is that of the tourist industry. Traditional holiday resorts in Italy, France, Spain, Greece, and other Mediterranean countries are becoming increasingly overcrowded during the summer season and are generally too well known. Tourists are therefore looking for new places to visit, off the beaten track. Libya has three attractions for tourists from Europe and North America, who are the mainstay of the international tourist trade: (1) a sunny climate, mild in winter and seldom excessively hot on the coast even in midsummer, with many sandy beaches, and a variety of landscapes, including deserts, oases, and mountains; (2) interesting Greek, Roman, and Islamic antiquities, and the battlefields of the Second World War; (3) Libyan life has a distinct African and oriental flavour, reflected in the customs and dress of the people, in the town and village bazaars, in the mosques, and desert Bedouin encampments.

At present, however, modern hotels, organized transport by road and air, and other tourist amenities, are lacking. Here are opportunities for the enterprising to build beach resort hotels and to organize motor coach and air transport to meet the contemporary preference for group holiday travel. The report says notably " For the construction of the new hotels required, every effort should be made to attract foreign investment. Foreign hotel and transport interests would be particularly welcome as investors because they are well placed to secure their own clientele . . . Private enterprise should also be given every encouragement to promote internal air travel. Special charter flights organized by one tourist agency at Easter, 1959, to take parties from Tripoli to Gadames and back were apparently successful, and more desert trips of this kind can be envisaged in future, especially if the hotel at Gadames is renovated . . . The proposal to hold an International Fair in Tripoli in 1962 lends urgency to the task of improving amenities for tourists . . . "

Of outstanding interest are the report's recommendations that £3,400,000 should be spent over the next five years to develop the supply of electricity. Intending contractors would, however, do well to study the experience of an American firm which undertook to supply turbogenerators and ancillary equipment and ran into every kind of difficulty and frustration, created not by local ill-will but by happy-go-lucky attitudes towards normal business procedures. The moral would seem to be to vet every project from all angles and to have everything written into the contract.

Minerals, other than oil, appear to offer few prospects for immediate development, although the potash deposits at Marada might be suitable for exploitation now that natural gas has been discovered in the vicinity.

In conclusion, it emerges from the report that any firm toying with the idea of venturing into this market of enormous potentialities, should waste no time, because it has already aroused great interest, especially in Italy. Pioneer firms must expect snags, but once they have learned the local ropes, they have the advantage of being several jumps ahead of late comers.

JOSSLEYN HENNESSY

Trade Publications

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Plant and Equipment

Vacuum Flash Evaporators. RICHARDSONS, WESTGARTH AND CO. LTD., P.O. Box 2, Wallsend, Northumberland. A technical survey of a new type of evaporator describing design and function with drawings and flow diagrams. 8 pp. ill.

Electronic Metal Detector. METAL DETECTION LTD., Moseley Street, Birmingham 12. Device protects machinery handling carpet or cloth against damage by needles, nails, etc., by generating a signal from the metal particle which stops the machine and gives an alarm. Double-sided leaflet, ill.

Filters. ZWICKY LTD., Buckingham Avenue, Slough, Buckinghamshire. Booklet provides full information of Uniplex and Biplex filters and includes photographs, diagrams, tables of dimensions, a standard specification and a pressure-drop graph for fluids of various viscosities. 12 pp. ill.

Continuous Heat Exchanger. HOLDAN ENGINEERS (LONDON) LTD., 119 Victoria Street, London SW1. A completely revised brochure on the " Holo-Flite " Processor, which is designed as a screw conveyor with helical, hollow flights through which the heat transfer agent is circulated. Operation, applications and constructional details are provided. Publication No. 201, 8 pp. ill.

Bench Assembly Trays and Storage Bins. KABI (ELECTRICAL AND PLASTICS) LTD., Cranborne Road, Potters Bar, Middlesex. Leaflet describes range of interlocking plastic trays and bins arranged for stacking, also Plastibox multiple bin installations. The Polybox design of nesting or stacking bins is described. 8 pp. ill.

Laboratory Balances. SOILTEST, INC., 4711 W. North Avenue, Chicago 39, Illinois. Bulletin describing lightweight laboratory balances designed for engineering and scientific research, routine testing and educational work. Triple beam models, with self-aligning bearings. Double-sided, ill.

Sealed Quench Slipper Furnace. WILD-BARFIELD ELECTRIC FURNACES LTD., Elecfurn Works, Otterspool Way, Watford By-Pass, Watford, Hertfordshire. An introductory account and specification of a unit providing controlled atmosphere conditions for the clean hardening of small parts, such as miniature bearing cages and races, and watch and instrument components. 950° C operating temperature; slipper size: 4 in wide by 6 in long. Double-sided, ill.

New Books

Mathematics in Your World. By KARL MENNINGER. *G. Bell and Sons.* (21*s*)

Writing to broaden the mathematical horizons of the ordinary reader, the author makes mathematics readable. Humour and ingenuity abound.

Rockets. By PAUL ADORIAN. *Paul Adorian, 21 Denmark Street, London, WC2.* (8*s*)

The history of rocketry is summarized and an investigation made of the application of rocket propulsion to various forms of transport. There are some speculations on space travel. This is a reprint of a paper read, in January 1929, to the Engineering Society of the City and Guilds College. The net proceeds from the sale of this publication are to be given to the Henry Tizard Memorial Fund. See also " Plain Words," p. 133 of this issue.

Atlas of the Other Side of the Moon. Edited by N. P. BARABASHOV, A. A. MIKHAILOV and YU.N. LIPSKIY. *Pergamon Press.* (50*s*)

Analysis and catalogue of the data obtained by the artificial lunar satellite launched on 4 October 1959. Thirty photographs and a map of the other side of the moon are appended.

Applied Optics and Optical Design. By A. E. CONRADY. Part 2. *Dover Publications, New York; Constable, London.* (13*s*)

The systematic study and design of nearly all types of optical system are taken up, with special reference to high-power microscope objectives and anastigmatic photographic objectives.

Technical Optics. By L. C. MARTIN. Volume 2. 2nd Edition. *Isaac Pitman.* (63*s*)

An introduction to—and a guide to further study of—the design, construction and performance of optical instruments. Among the recent important advances taken up in this edition are the specification of optical performance in terms of the contrast transfer factors and interferometric testing. Honours degree students, scientific instrument makers and ophthalmic opticians should find this book invaluable.

Tensor Analysis of Electric Circuits and Machines. By L. V. BEWLEY. *Ronald Press Company, 15 East 62th Street, New York 10.* ($12)

The essential principles, together with applications, of Kron's matrix-tensor methods are presented. The book is designed to provide a unified consolidation of developments in this subject and to serve as an introduction (the standard is about honours degree level) to tensor methods in electrical engineering.

Metallurgy for Engineers. By E. C. ROLLASON. 3rd Edition. *Edward Arnold.* (20*s*)

A considerable amount of up-to-date material has been incorporated in this completely revised edition. Zone refining, stereographic projection, pole triangles and figures, titanium and the nuclear energy metals are some of the new items.

Textures in Metal Sheets. By F. A. UNDERWOOD. *Macdonald.* (28*s*)

Addressed to those starting the study of textures, this monograph is largely concerned with X-ray diffraction methods and apparatus.

Graded Exercises in Technical Drawing for Secondary Schools. By W. G. BEETLES. 2 Volumes. *Hutchinson Educational Limited.* (Teachers' book 15*s*, Students' book 10*s* 6*d*)

Designed specifically for class work, the two books have a common set of " fruitful and snag-free " exercises. Hints on the teaching of technical drawing preface the teacher's volume.

The Technical Illustrator. By HUBERT COOK. *Chapman and Hall.* (35*s*)

It is assumed that the reader has a basic knowledge of perspective and trimetric projection, and can draw reasonably well. The book is suitable for students preparing for the City and Guilds examinations in industrial art.

The Reviewers

Dr. T. Lonsdale, M.Sc., F.Inst.P., was for some years the officer in charge of information services at the Road Research Laboratory in the Department of Scientific and Industrial Research. He has also worked with the Ministry of Transport.

Mr. W. U. Sirk holds a Diploma in Applied Mechanics (Sheffield), and is at present employed as a research engineer in the Machine Dynamics Section of P.E.R.A.

Mr. M. J. B. Scanlan, B.Sc., A.R.C.S., is a senior engineer with Marconi's Wireless Telegraph Company Limited.

Mr. Jossleyn Hennessy, M.A., is an economist, broadcast commentator and London editor of the *Eastern Economist*, New Delhi. He is the author of several books, including *The European Common Market: What Will it Mean to You?*

Marketing

Moulded Product Firm Join Mycalex

ROSITE Limited, until now one of the PLESSEY GROUP of Companies, has become a subsidiary of MYCALEX and TIM Limited, of Cirencester.

Plessey have stated: "Rosite Limited was set up in association with ROSTONE CORPORATION, of Indiana, in 1957 to manufacture in this country a range of cold moulded insulating products for use in the electrical industry. This range has proved highly successful and British designers are specifying the material on an increasing scale.

"It has become obvious that to keep pace with current technology Rosite must broaden its base and, as announced recently, is already involved in a substantial development programme in hot moulded materials. Such developments are outside basic Plessey product policy and in order to accelerate these developments, Plessey has withdrawn in favour of Mycalex who are already widely experienced in this field. The interest of Rostone Corporation is maintained unaltered by this new arrangement."

Plessey add that the move of production equipment to Cirencester will be spread over some months and deliveries and current development work will in no way be impeded by the move.

When the move has taken place none of the employees working on Rosite is likely to be adversely affected for it is anticipated that work will be available either at Plessey factories in Swindon or with Rosite at Cirencester.

The Woman Executive and Advanced Management

Qualified women executives between the ages of 36 and 50 years holding senior management positions in business and industry will be admitted to the 41st session of the Advanced Management Program of the Harvard Graduate School of Business Administration.

Dean Stanley F. Teele, in announcing that the AMP Admissions Committee will accept applications from senior women executives for the session which begins on 18 February, 1962, states that the number and role of women executives in such top-management positions today and in the future makes it important that the School offer its executive development activities to them on the same basis as it has to men for the past 18 years.

The Advanced Management Program is a 13-week course of study for executives holding senior management positions in government and industry. Participants live, study, and attend classes at the Harvard Business School. To be admitted they must be between the ages of 36 and 50 years, be sponsored by their companies or organizations, have 10 to 15 years of business experience, and hold senior policy making positions. All applicants are screened by a faculty admissions committee.

Over 5,000 executives have graduated from the Programme. The School has high hopes that this Programme will make as significant a contribution to the woman executive and her company as it has to the male executive and business organization.

Export Opportunity in Malta

The Sheffield firm of G. B. TOLPUTT Limited, manufacturers of hand-made "chunky" jewellery, have received approval from the MALTA AIDS TO INDUSTRIES BOARD for their application to set up a factory on the island at Msida, in the name of MÒDA (MALTA).

The factory will start by employing 22 people but by the third year there is expected to be a staff of 54, their output being exported to world markets.

G. B. Tolputt has been producing modern high-class hand-made jewellery for the past two and a half years. The company's UK sales have doubled every six months, leaving not much room for a strong export drive. The setting up of the branch factory in Malta will go a long way to remedying this, acting as the export opportunity end of the business.

Mr. G. B. Tolputt started the business from scratch. Three years ago, he says, he knew nothing at all of the jewellery trade. With his wife at his side designing products, which are wrought mainly in copper, Mr. Tolputt expanded the business in 30 months to a stage where the company has accounts with shops in nearly every town in the British Isles.

One of his reasons for choosing to locate his export factory in Malta was the excellent workmanship and the tradition of hand work. The relatively low cost of good work-people was another reason.

"In Malta," says Mr. Tolputt, "we have found a formula which enables us to maintain our prices in the export world. We are delighted with the factory allocated to us and we hope to be in production in time for the 1962 Spring trade."

Ford at Halewood to Use AEI Motors

The FORD MOTOR Company has specified that all electric motors for their new factory at Halewood, on Merseyside, are to be made by ASSOCIATED ELECTRICAL INDUSTRIES.

Orders obtained by AEI for this factory total £167,000. They include electric motors from ½ hp to 850 hp, to be supplied by both AEI Motor and Control Gear and Heavy Plant Divisions; and three 12,500 kVA, 3 phase transformers which will be made by AEI Transformer Division.

One of the orders, placed by ANDREW AIR CONDITIONING with Motor and Control Gear Division, is for 56 squirrel-cage motors of various types ranging in size from 12½ to 75 hp, for driving air conditioning fans; another, from HARLAND AND WOLFF Limited, is for 69 squirrel-cage and slipring motors from ½ hp to 150 hp for operating car body presses. A third order, from VICKERS-ARMSTRONGS Limited, also specifies motors for driving presses and covers 13 slipring machines each rated at 75 hp.

Other contracts cover the supply of four 70 hp squirrel-cage motors through John Lysaghts and Company for fan drives and ten pump motors rated from 125 to 150 hp through Hayward Tyler and Company. In addition, AEI motors will power the cranes being supplied by J. H. Carruthers and Company and the conveyor equipment by G. S. King Limited.

Equipment being supplied by the AEI Heavy Plant Division for Halewood includes motors for driving reciprocating air compressors by Alley Compressors Limited. They include five 850 hp, 600 rpm, 0·8 pf synchronous induction motors, two 230 hp, 428 rpm, 0·8 pf synchronous induction motors, together with liquid rotor-starting and field control cubicles.

The transformers ordered from the AEI Transformer Division cover the three main 3 phase units required for the factory. Each is rated at 12,500 kVA with a voltage ratio of 33/11 kV, and fitted with AEI high-speed resistor transition on-load tap changers.

Bristol's New School of Chemistry

HOLLAND & HANNEN AND CUBITTS (GREAT BRITAIN) Limited are to build a chemistry teaching block for Bristol University under the university's scheme to build a new School of Chemistry at a total cost of around £1¾ million. The teaching block contract is worth £630,000.

Work on the teaching block is due to begin in September. Research blocks, lecture theatres, library and other buildings are to be added by 1965. The site preparation contract for the School of Chemistry is already being carried out by Cubitts who are also building the university's new Medical School—at a cost of £1,200,000.

Architects:	Courtaulds Technical Services Limited, Foleshill Road, Coventry.
Consulting Engineers:	Courtaulds Technical Services Limited.
Main Contractors:	Holland & Hannen and Cubitts (Great Britain) Limited, South West Area Office, 13 Dowry Square, Bristol 8.
Quantity Surveyors:	Courtaulds Technical Services Limited.

AEI Contract for Mine Winder

The West Midlands Division of the National Coal Board has placed an order with ASSOCIATED ELECTRICAL INDUSTRIES, Heavy Plant Division, for an 1,840 hp single-drum ac winder for Victoria Colliery, near Stoke-on-Trent.

Dynamic braking will be employed, and winder control will be obtained by the use of rotor contactor-gear and metallic resistances instead of the more conventional liquid controller. Two of the main advantages of the control system to be used are, firstly, that since no mechanical linkages are involved, the control equipment can conveniently be installed wherever space is available, and secondly, that very little maintenance is required.

Another interesting feature of this installation is that the winder motor will be wound for a 2,500-volt supply but can be re-wound for 3,300 volts when the supply is altered. The switchgear and reversing contactors are suitable for both voltages.

The winder motor and metallic motor resistances will be made at AEI's Rugby Works and the mechanical parts of the winder are to be manufactured by Fullerton, Hodgart and Barclay Limited.

A similar winder was supplied by AEI in 1955 to the NCB for Barony Colliery in Scotland.

London Office for John Thompson Group

The John Thompson Group of Engineering Companies have opened a new building in Woburn Walk, Duke's Street off Tavistock Square, WC1, the purpose of which is to bring under one roof the complete London sales force of the 17 home companies controlled by the group.

The original concern was founded 135 years ago as makers of iron canal boats and boilers. Since then there has been rapid expansion and, in addition to the 17 British based companies, 12 more are active in various parts of the Commonwealth and considerable diversification of interest has taken place. Group products now include, besides the complete range of steam raising plant, pressure vessels, motor chassis pressings, conveyors, industrial and chemical plant fabrications. The precision engineering branch specializes, in the design and manufacture of special purpose machinery.

The latest activity is the production and sale of American style electric cookers which, bearing the name "Thompson-Tappan," are made by the John Thompson Instrument Company Limited.

Mixer Equipment for Australian Plant

CRANE Mechanical Shaft Seals were fitted to 14 of 47 LIGHTNIN Fluid Mixers recently sent to Australia for use in a new synthetic rubber plant of the AUSTRALIA SYNTHETIC RUBBER Company.

Thirty-three mixers were without seals as they are to be used in open tanks. The mixers were designed and built by Lightnin Mixers, of Poynton, Cheshire. They are to be used on Latex reaction vessels handling the fluid at a pressure of 150 lb per sq. in and at a working temperature of 150° F.

Crane Type 109 Double Seals were used in this application, consisting of an arrangement of two single seals mounted back to back. Sealant is circulated between the two seals at a pressure equal to the service pressure—150 lb per sq. in.

CRANE PACKING Limited is a member of the TUBE INVESTMENTS Group.

Overhead Cranes for RTB Subsidiary

The Manchester crane makers, S. H. HEYWOOD and Company, are to make a 20 ton and nine 5 ton overhead travelling cranes for H. F. SPENCER of Wolverhampton.

The £53,000 contract has been placed by RICHARD THOMAS AND BALDWINS, parent company of H. F. Spencer. Steel strip and steel sheet, supplied by RTB are cut up and stored by the Wolverhampton company.

The overhead cranes have a 70 ft span. The 20 ton model will be equipped with an operator's cage. The 5 ton cranes are to be arranged for travelling pendant push-button control.

Delivery under the contract is to begin at the end of this year and be complete by early 1962.

Agitation and Agitators

Agitators are used in a wide range of chemical processes, and in recent years great strides have been made in solving the many chemical and mechanical engineering problems involved.

By R. W. Snudden, B.Sc.(Eng.)

Imperial Chemical Industries Ltd., Plastics Division

THE chemical engineer must first examine the object of the agitation and then decide the type of agitator to be used to achieve this object. The mechanical engineer is concerned with the driving mechanism and very often with sealing the driving shaft on its entry into the agitated vessel. These various aspects are discussed below.

Objects of Agitation

A process may require agitation for one or more of the following purposes:

(1) Mixing of Two or More Liquids

These may be miscible or immiscible. In the case of miscible liquids the role of agitation is usually to achieve mixing in the shortest time. In the case of liquids of equal density, agitation accelerates a process which, if the liquids were left for some time, would be carried out by molecular diffusion.

When immiscible liquids are mixed, the object of agitation is usually to initiate and maintain as a uniform dispersion, small droplets of one liquid within another. The agitator must provide good circulation throughout the liquid volume and high shear rates in the region of the impeller to break down and reduce droplet size.

(2) Dispersion of a Solid in a Liquid

The solid may be heavier or lighter than the liquid and either soluble or insoluble. For solids which are heavier than the liquid, the agitator must produce upward circulating currents of sufficient strength to overcome the natural tendency of the solid particles to fall to the vessel floor, and for those which are lighter, the downward circulating currents produced must be able to sink the solid in the liquid.

For the solution of a solid in a liquid, correct agitation, while taking account of the points mentioned previously, will help the solids to dissolve quickly and efficiently. Solids are more quickly dissolved in regions of the vessel where the liquid is subjected to high rates of shear.

For the suspension of a solid in a liquid the agitator must provide good circulation throughout all the liquid volume in order that a uniform suspension is maintained. The points mentioned previously with respect to heavier and lighter solid particles are of particular importance here.

(3) Mixing of a Gas with a Liquid

The aim is generally to disperse the gas throughout the liquid in order that chemical reaction may take place. High shear rates in the region of the impeller together with good circulation are usually required. The position and type of gas entry is often of importance.

(4) To Promote Heat Transfer between a Fluid and Its Containing Vessel

Many reactions involve the addition or removal of heat. The rate of heat transfer between the fluid and the vessel wall and the dispersion of heat through the fluid are both markedly increased by the turbulence created by agitation.

Types of Agitator

With some exceptions, agitators fall into two broad classifications, those which produce centrifugal flow and those which produce axial flow. The first group includes the paddle and turbine types of impeller while the second includes the propeller-type agitators.

The centrifugal impeller is usually mounted low down in the containing vessel and produces spiral rising currents near the wall of vessel and spiral currents in the downward direction near the impeller shaft and thus promotes circulation throughout the vessel. A secondary circulation also occurs beneath the impeller. As the liquid streams from the impeller it is subjected to high rates of shear due to the eddies which are formed at the blade tips. Swirl velocities are produced by the agitator and their magnitude at the vessel walls can be of importance where heat transfer at the wall is a process requirement.

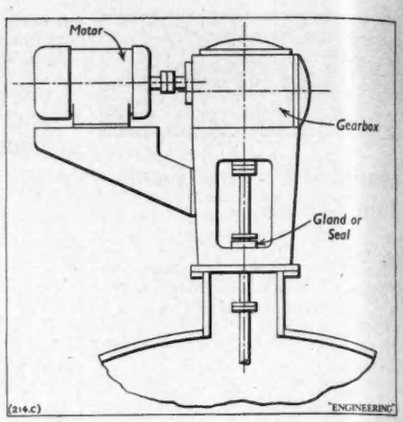
The magnitude of the factors which make up the flow pattern within the stirred vessel will be dependent upon the agitator size, geometry, the speed of rotation, the physical properties of the liquid and the size and shape of the containing vessel. In order to produce a uniform flow pattern, impellers which are centrifugal in action are usually mounted vertically at or near the axis of the vessel. They are either top or bottom entry; space, access, or process requirements usually dictating which is chosen.

The axial flow impeller also finds use mounted in a similar way to the centrifugal impeller but is also able to produce adequate agitation from side entry or vertical angled and offset mountings. Liquid is drawn through the impeller and a forward axial velocity is imparted to it. The resultant stream entrains further liquid and a general circulation is maintained. Shear is produced at the impeller and also in the entraining layers. Axial flow impellers are usually small with respect to vessel dimensions and often operate at high speed.

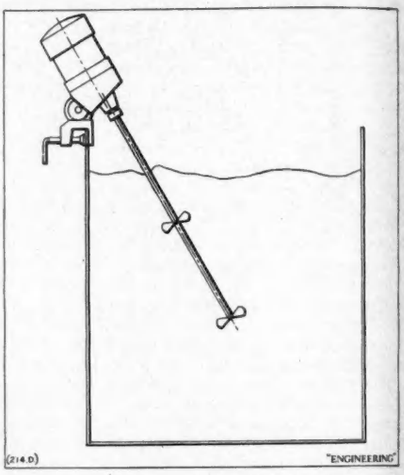
Centrifugal and axial flow impellers are sometimes used in pairs on a common shaft.

Many permanently installed agitators are of the centrifugal flow type although this is not usually the case where the agitator has a side or angled entry, while portable agitators are largely of the axial flow type since they can be made to operate efficiently from almost any position.

A process will usually require that circulation, shear and swirl are present to varying degrees. An efficient agitator which is designed to perform a specific task will maintain the correct balance between these quantities. Correct vessel design will aid this. In some instances it is found that baffles are essential when a vertical, centrally mounted impeller is used. Baffles generally increase the rate of vertical circulation in the vessel.

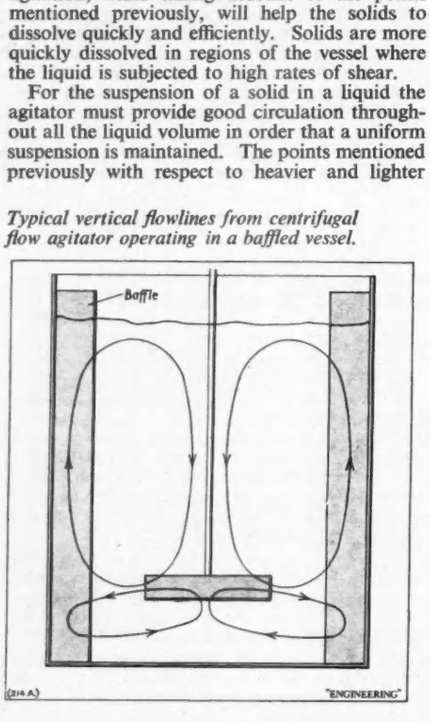


Diagrammatic arrangement of integral stirrer drive for direct mounting on vessel nozzle.

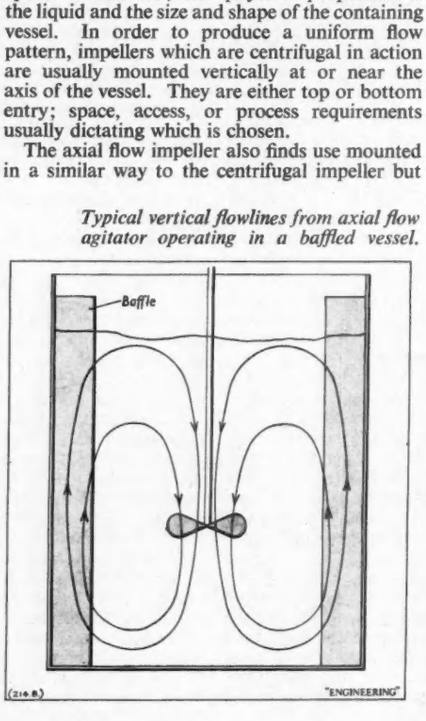


Diagrammatic arrangement of geared portable agitator with tank side-mounting bracket.

Typical vertical flowlines from centrifugal flow agitator operating in a baffled vessel.



Typical vertical flowlines from axial flow agitator operating in a baffled vessel.



Mechanical Design

The mechanical design of an agitator is somewhat akin to the design of a rotary pump, but the conditions of installation and operation are often more severe. The agitator shaft may have a long overhang and is sometimes subject to severe bending loads. The agitator is commonly driven by an electric motor through reduction gearing. The motor and gearbox are mounted in some way on the vessel and must be

aligned with one another and with any gland or bearing in the cover of the vessel. The arrangement clearly presents greater difficulty than a directly driven pump mounted on a rigid bedplate, but these difficulties are minimized in designs in which the motor, gearbox and gland are built into an integral unit fitted directly to an opening in the vessel.

It is important to remember that the gland should not be subjected to load and should not be used as a steady, hence careful consideration must be given to its position with respect to the shaft bearings. Wear will be accelerated if the shaft is misaligned or if it is allowed to bend or vibrate. Accessibility for adjustment must further be borne in mind.

Further detailed mechanical requirements are as follow :

(*a*) The impeller faces must be well finished so as not to spoil the blade profile. Flow across the blade must be unobstructed; this is of particular importance in the case of high speed agitators.

(*b*) As far as possible the design should be free from cavities and similar areas where build-up can be initiated.

(*c*) The shaft must be sufficiently stiff for the agitator to run continuously within its range of design speeds without vibration. Symmetrical impeller design will aid this.

(*d*) It is preferable that the drive can absorb such things as sudden loading, and knocks which may occur if the assembly is misused.

(*e*) Since agitators may be used for various processes, the ability to change speed readily is advantageous as is the ability to change the position or type of impeller.

(*f*) For general purposes, the shaft and impeller should preferably be made of suitable stainless steels although in certain instances, other special materials may be preferred.

(*g*) The design must take account of the safety regulations which are operative in the area in which the agitator is to be used or is liable to be used.

(*h*) For side entry and bottom entry installations in vessels of large volume, it should be possible to change the glands, seals, etc., without having to drain the vessel.

(*i*) Lubrication as routine must be kept to a minimum by the use of automatic devices or sealed systems. Other general routine maintenance which might be necessary must be easily and quickly performed.

Most of the foregoing details apply more particularly to static installations but they must also be considered in the design of portable agitators when points (*e*), (*f*) and (*g*) are of particular importance.

Portable agitators must essentially be compact units and it must be possible to install them with a minimum of fixtures, supports, etc. A favourable type is that which may be clamped to the side of an open vessel by means of a universal fixing bracket. Axial flow impellers are preferred for this type. Operation in vessels of large diameter is usually more successful if the vessel is unbaffled since baffles tend to spoil the circulation in this case.

A Selection of Portable Mixing Equipment

Some of the types of portable mixing equipment available are described here. This article is not intended to be comprehensive but to illustrate the range of machines which are designed today.

Contemporary Approach

Lightnin Mixers Limited, Poynton, Cheshire.

Typical of a modern range of portable mixers are those produced by Lightnin. Designed with contemporary styling they are a complete integral unit.

Fig. 1 shows the general construction and some of the features of the range are worth mentioning.

The positive drive chuck is quick acting, simple to operate and is positioned above the maximum liquid level. Tightening the grip-screw forces it to bear against the flat on the mixer shaft, ensuring a positive drive. A safety feature includes a slight taper on the flat. The shaft cannot drop out unless the grip is intentionally released, and it is said to be impossible to insert the shaft in any position except the correct one.

For the gear-drive units a single reduction set of internal helical gears is fitted. By using internal gearing the makers claim the following advantages: (*a*) Direct and gear drive units for the same direction of mixer-shaft rotation; (*b*) shorter gear-centre distance means a more compact drive and better appearance; (*c*) greater length of tooth contact; (*d*) reduced sliding action of the gear teeth with less friction and wear; and (*e*) greater strength and longer life. Under normal operating conditions no maintenance or re-lubrication is required for 5 years.

The internal gear is mounted on the drive shaft using a tapered ring assembly known as "grip springs." These tapered rings provide a keyless friction drive between the gear and the drive shaft. This feature gives the advantage of built-in shock load protection. The grip springs are set at 150 per cent full load torque and should the torque exceed that value, the gear will slip before the mixer is damaged. The drive can be made ready for service again by retightening the locknut.

One of the more important features of the mixer is the positioning arrangement of the clamp assembly. On the mixer housing assembly are numbers which indicate the vertical angle of the mixer shaft. On the rim of the clamp socket are letters to indicate the horizontal angle of the unit. This provides a simple way to instruct the operator just how to locate the mixer for the best results.

A damping pad between the housing ball and the clamp socket reduces vibration. In many instances this permits the use of longer shafts.

Because the propellers used are geometrically similar it means that the laws of fluid dynamics can be used to predict the performance for scale-up calculations. The designs were selected to give the best combination of flow and head characteristics for the range of portable mixer applications.

Special Purpose Mixers

Kestner Evaporator and Engineering Company Limited, 5 Grosvenor Gardens, London SW1.

Among the range of portable mixing equipment available from this company are four units which merit special attention.

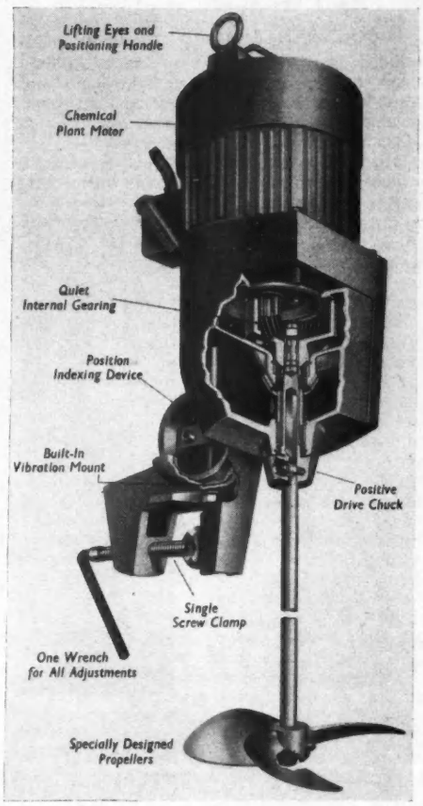


Fig. 1 Contemporary in design and appearance. (Lightnin Mixers)

Fig. 2 This twin unit can produce two separate zones of agitation. (Kestner)

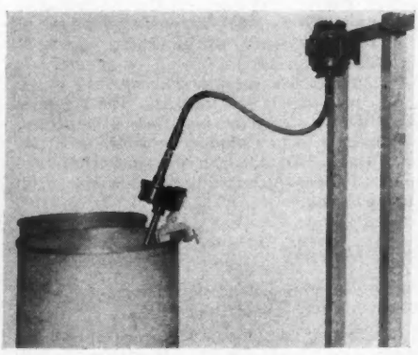


Fig. 3 This arrangement allows one prime mover to serve several mixing tanks. (Kestner)

The twin shaft unit shown in Fig. 2 has been designed primarily for the more difficult mixing problems. It can produce two separate zones of agitation, thereby cutting out swirl and vortex formation without the need for any form of baffle within the vessel.

A variation of the electrically-driven portable mixer is that shown in Fig. 3, the prime mover being isolated from the actual mixing tank. The drive is transmitted to the mixing head and bearing assembly by a flexible drive. This arrangement can be used to serve a number of mixing tanks and in some cases the motor can be positioned on a runway above the tanks.

Of special interest is the compressed air

operated unit. The standard machine is fitted with a ½ hp, 1,120 rpm rotary-vane air motor and quick-release coupling. The air motor is completely flameproof and a wide variation of speed can be obtained. The makers say it is very much lighter than the comparable machine driven by a flameproof electric motor and cannot be damaged by overloading.

Some time ago, Kestners developed a reciprocating paddle stirrer for milk. This stirrer sets up an agitation similar to a hand-operated paddle, sufficient to maintain complete homogeneity, but not strong enough to bring about undesirable churning effects. This unit was taken up by fruit squash manufacturers who wish to keep their fruit in suspension without macerating it and it has now been adopted in industries where materials are not widely different in specific gravity and where violent agitation would be detrimental to the product and wasteful of power.

The unit can be powered by electric motor, belt drive, or by an air-operated motor which is more portable and considerably cheaper. The paddle normally runs at 10 to 15 strokes per min, but the screw-down air valve enables the speed to be adjusted to anything between 3 and 50 strokes per min. The unit is said to be particularly light.

Dynamically Balanced

Aiton and Company Limited, Stores Road, Derby.

Included among this company's range of fluid mixers known as PWV, are lightweight and industrial portable clamp-mounted and semi-portable bracket-mounted mixers operating at 1,440 and 960 rpm. See Fig. 4.

This range covers from ½ to 3 hp. In order to produce a strong and efficient unit with a long trouble free life and yet one which was lightweight, the makers chose a robust aluminium alloy housing with a double-row self-aligning ball bearing placed well below the motor to give adequate support to the shaft. A generous shaft diameter is used and the operating speed kept well away from the critical speed.

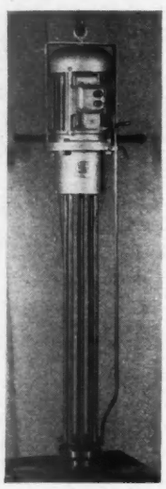


Fig. 4 (below) The whole unit is dynamically balanced after assembly. (Aiton)

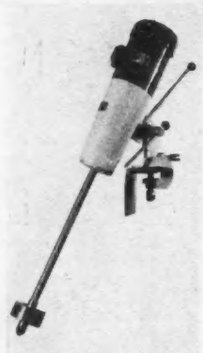


Fig. 5 (right) The mixer has an impeller revolving inside a stator fitted with radial baffles. (Greaves)

Aitons take great care to avoid vibration in their units so that all the power is applied to mixing. The shafts are carefully aligned and the whole unit is dynamically balanced.

An angled-blade turbine impeller is fitted as standard though the type of impeller can be varied if required. This type of impeller is said to combine excellent side-to-side and top-to-bottom mixing which gives the best results in most mixing processes. The turbine is fitted with a stabilising ring which prevents sideways movement of the shaft and is particularly useful when the liquid level is drained below the mixer while it is operating.

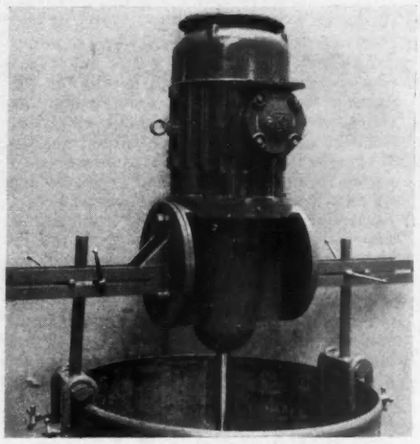


Fig. 6 The larger high speed cavitation dispenser units with double supporting clamp. (Torrance)

Cavitation Dispersers

Torrance and Sons Limited, Bitton, Nr. Bristol.

Dispersers of the suspended type are available in a wide range. Such units are used for suspending over existing containers and supporting and steadying clamps are included. They are frequently used with an overhead electric hoist for lifting purposes. The larger units have double supporting clamps as shown in Fig. 6.

For the 2 hp unit, which is the standard portable type, the rotor speed is approximately 2,800 rpm on load. The rotor is a stainless steel 4 or 5 in diameter cavitation type.

The units can be used for the manufacture of emulsion paints and other processes, and the makers say that no other plant is necessary.

High Speed Mixers

Joshua Greaves and Sons Limited, Ramsbottom, Bury, Lancashire.

Among this company's range of mixers the HS series are particularly interesting (Fig. 5). The makers claim this mixer is capable of mixing a greater variety of materials than other machines of comparable horsepower. They also state that it is possible to produce emulsion paint from start to finish in a single operation.

The mixer consists of an impeller revolving inside a stator fitted with radial baffles. These break down the particle size by impact and create a high rate of shear. The liquids are then forced, at high pressure, upwards against the deflector, which disperses them to the sides of the vessel. They then flow downward to the base of the container and continue the circulation through the mixer head.

Because the mixer head is unobstructed by sleeves or narrow apertures, it is virtually self-cleaning when immersed in a solvent. The drive to the mixer is through a flexible coupling and a sealed ball-bearing supports the centre shaft. A selection of materials is available for the mixer head steady bearing all of which are self-lubricating.

All moving parts are protected and the mixer can be handled while in motion. The operator can hold the machine in a container, if necessary, and guide it to any required position. Speeds vary from 1,500 to 3,600 rpm and laboratory models up to ½ hp are infinitely variable from 0 to 7,000 rpm.

Turbo-Stirrers

Moritz Chemical Engineering Company Limited, 204 Earls Court Road, London SW8.

This company manufactures a range of portable Turbo-Stirrers suitable for handling batches from 80 to 4,000 gallons.

An impeller, carefully designed in shape, position and number of blades, and driven at high speed by an electric motor comprises the working part of this stirrer. When it is set in action a depression occurs causing a continuous suction of the liquid or viscous mass towards the centre container. Under the action of the impeller the mass, already divided into currents or streams, is thrown against the blades of the stationary casing, dividing the currents still more and forcing them to intermix thoroughly within the mass.

Moritz say that not only is mixing better but that handling time is greatly reduced.

In addition, this company make a range of high speed turbo-reactors with a capacity of 10 to 330 gallons. These run at very high speeds with a fine clearance between the stator and the rotor. They can be used as an effective homogenizer.

Air-Driven Motor

D. J. Osborne Company Limited, 66A Canterbury Road, West Croydon, Surrey.

In addition to the conventional electric motor driven agitators this company makes, there is also a useful range of air-motor driven agitators available.

These are particularly useful where flameproof conditions are required and they show a great advantage in weight ratio. This is because the weight of an air motor is only a fraction of that of a comparable hp flameproof electric motor, and the overall size of the unit is smaller which makes them particularly adaptable for laboratory use.

Fig. 7 Type IV model mixer. It has a ½ hp air motor giving 0 to 1,000 rpm. The weight is 15 lb. (Osborne)

Another advantage of this equipment is an obtainable speed variation from say 0 to 1,000 rpm, whereby the speed is easily adjustable by varying the air pressure with a regulator. The hp range is from ⅛ to ¾ hp and depends on the air pressure available which is normally 80 to 100 lb per sq. in. Air-motor models are supplied as portable or permanently mounted units subject to suitable air supply being available.

In addition to making a large range of portable mixing equipment, this company produces mixers for heavy duties as well. Their complete range is from ⅛ to 150 hp for free-flowing mixing applications.

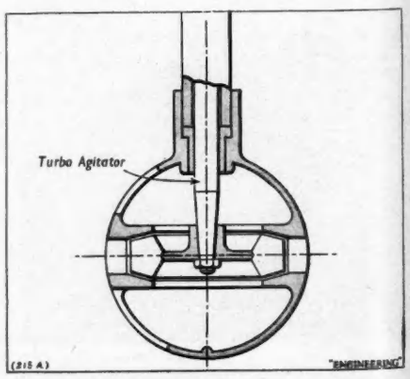


Fig. 8 Impeller of the Turbo-agitator. (Moritz)

Fast-Discharge Heavy-Duty Capacitors

Research scientists at the Atomic Weapons Research Establishment, Aldermaston, have developed 10 kilovolt, 10 microfarad capacitor units which enable currents of up to a million amps to be realized with a minimum of energy storage (5,000 joules). Such devices, which also have a very small rise time, are of significant value in controlled thermonuclear research (ctr).

An important feature of the capacitors is the low-inductance connections that they employ. These consist of metal foil strips separated by extremely thin insulating material—0·006 in for 10 kv and 0·06 in for 100 kv.

To protect them from humidity and improve storage life, the capacitors may be cast, or "potted," in blocks of resin.

Other applications besides ctr experiments include high speed photography and research on hypersonic flight, using the high-temperature shock tube technique.

In a test, one unit having a capacity of 10 microfarads and a working voltage of 100 kilovolt, was charged and discharged through a low-inductance switch 10,000 times without a breakdown. On this occasion, the ringing frequency of the discharge was 1 Mc/s and the current 700,000 amps.

The United Kingdom Atomic Energy Authority have granted licences for the manufacture of these devices to several companies in Great Britain. Further information is available from the Patents Licensing Officer, UKAEA, 11 Charles II Street, London SW1.

Proposal for a Solar Satellite

A space probe able to send an uninterrupted stream of scientific data from close to the sun's surface could be put into solar orbit in about five years, according to a statement made by the US General Electric Company.

Preliminary designs for such a project were presented at a recent joint meeting of the Institute of Aerospace Sciences and the American Rocket Society, held in California. The 250 lb probe vehicle would be able to survive solar proximity and would be held steady in orbit without use of its stabilization system.

The vehicle would be launched into an elliptical orbit, the closest point or perihelion of which would be about 9 million miles from the sun. The satellite would return to the earth's distance from the sun, 92,900,000 miles, at the orbit's aphelion, and would circle the sun every five months. The Saturn rocket scheduled for use in about 1965 is theoretically capable of placing the probe into such an orbit.

Once the vehicle was in orbit and separated from the rocket, a system of sun or star trackers and gas jets would provide initial orientation. From there on, the probe would be held steady by a combination of orbital forces and the "pressure" of the sun's rays.

The probe would have central cluster of equipment that would include a dish-shaped solar collector aimed into the sun and a system for converting solar energy into electrical power. Telemetry equipment, the initial stabilization system, power converters and scientific experiments (such as studies of the interaction between magnetic fields and charged particles) would be contained in two cylindrical pods, at the ends of two booms extending outward and toward the sun from the central cluster. Passing through the central cluster would be a long aerial aimed at all times toward the earth.

Half the weight of the probe would be in the equipment pods at the ends of the booms. With the solar collector located behind the probe's centre of gravity, the "pressure" of the sun's radiation would hold the collector facing the sun. The weight of the extended pods would also counteract spinning. Adjustable shutters in the sides of the equipment pods would control the probe's temperature; excess heat would radiate into space through the open shutters.

The telemetry equipment called for would be pulse code modulated with phase shift keying (PCM PS) based on a "Synchrolink" system now under development by General Electric. This system has an extremely high theoretical efficiency.

A thermionic power conversion system has been selected because it can operate in the high temperatures to be encountered near the sun and over the wide range of solar flux encountered during the highly elliptical orbit. The more widely used photovoltaic cell system would degrade at those temperatures.

The solar probe's power conversion system would be unique in having its diodes arranged in a flat plate which could be moved into and out of the focal point of the solar collector. Other systems have the diodes arranged on a concave surface.

Natural Rubber for Road Surfacing

The current annual report of the Natural Rubber Bureau, just published, records good progress with the reorganization of three research units which are now all directly responsible to the Malayan Rubber Fund Board. The report states that, by last December, the reorganization "had been virtually fulfilled as far as administration in the United Kingdom was concerned."

The report mentions an important result achieved in research into rubberized road materials, in which the DSIR Road Research Laboratory and the Bureau are cooperating. It states: "A method of preparing a rubberized cut-back bitumen has been developed using latex in which the temperature of mixing has been kept below that at which degradation on any appreciable scale will occur. By this means, a cheaper form of rubber used more efficiently has resulted in a more economic binder and the disadvantage of foaming has been eliminated."

Progress has also been made in researches

The rubberised bitumen (on the left) is in good condition while the control (right) of ordinary bitumen shows some stripping, in an experiment recently conducted in Australia.

designed (*a*) to assess the value of adding sulphur to rubber bitumen, and (*b*) to devise methods of obtaining stable mixtures of rubber in tar.

Referring to full-scale road experiments, the report mentions further positive results. "In some of these," it comments, "there are indications of the superior qualities of the rubberized material when compared with the control materials. In particular, in the case of the rubberized bitumen macadam experiment on trunk road A15 at Yaxley, Huntingdonshire, the majority of the rubberized sections are showing a superiority over the normal bitumen macadam."

Incidence Angles for Solar Absorbers

The effect of inclination and orientation on the amount of incident solar radiation on a flat surface has been examined in Australia and is reported in the current Research Review of the Commonwealth Scientific and Industrial Research Organisation.

The angle of inclination to obtain equal incident energies at summer and winter solstices has been determined, and an expression derived which enables the inclination for maximum insolation over any period to be evaluated. As a close approximation, between latitudes of 15° and 45°, the daily insolation at the summer solstice is equal to that at the winter solstice when the inclination is 1·5 times the latitude. Maximum isolation over a full year occurs when the absorber is inclined at 0·9 times the latitude.

Neither inclination nor orientation is as critical as has been thought, and quite large departures from the optimum configuration can be tolerated without very significant reductions in incident energy. For example, in a latitude of 30°, a 45° deviation in orientation from due north will produce a reduction in mean annual insolution of only 5 per cent, as will a change in inclination from 0·9 to 1·5 times the latitude.

Aids to the Processing Industries

At a recent Press conference in London Dr. D. A. Dahlstrom, Director of Research and Development, Eimco Corporation, Utah, USA, spoke of current developments in the field of continuous filtration and sedimentation, industrial waste treatment and water recovery, and of the role played by Eimco (Great Britain) Limited of Gateshead and London.

Dr. Dahlstrom said: "With the increasing importance to all countries of the processing industries, and the simultaneous improvement in communications between peoples, the process equipment manufacturer must take as his motto: 'If you are to be a leader in your line of endeavour, you must be a leader throughout the world.' Furthermore, leadership must rest upon sound technological understanding both in equipment manufacture and its application.

"Eimco (Great Britain) Limited is one of the Corporation's most important sister companies bent on achieving this objective. Not only was it the first Eimco organization formed in Europe but it has shown steady growth, introduced new equipment and applications and expanded its role in the export of equipment to other countries.

"In the field of liquid-solid separation, the British company designs, manufactures, and installs the complete Eimco line of continuous filtration, sedimentation and clarification plant. Of particular importance have been its development of equipment for the production of titanium pigments, alumina, antibiotics, and for fine coal dewatering and industrial waste treatment. Many of these developments, while being aided by Eimco's work in other areas, have in turn assisted these applications in other countries.

"In new equipment advances in the field of continuous filtration, undoubtedly the greatest break-through has been the development of the continuous belt filter now known as the Eimco-Belt Filter. A search of the patent literature of 40 years ago would indicate that the basic principle of continuously cleaning the filter cloth (so that a fresh medium is always available) has long been recognized as being imperative in the achievement of the most efficient filtration. However, many problems in the practical application of the principle remained unsolved until the development of the EimcoBelt. The unit is now commercially available, after a five-year research and development programme of laboratory, pilot plant and full scale testing."

The development in the field of sedimentation of high torque machines to remove continuously the settled solids to the discharge point has been of importance. This has permitted the processing of a wider range of solids while producing higher solids concentrations in the underflows. Not only are processing costs reduced but greater recovery of valuable materials, either in the liquid or the solid state, can be achieved.

New Roller-Bearing Lubrication Formula

Theoretical research has been carried out at Leeds University on the lubrication conditions at contacts such as those between gear teeth. Recent experimental results from other laboratories have confirmed the theoretical findings and it is now possible to use a formula for the calculation of oil film thickness.

By D. Dowson, B.Sc., Ph.D., A.M.I.Mech.E., and G. R. Higginson, B.Sc., Ph.D., A.M.I.Mech.E.

IN RECENT years a major development in the field of lubrication of highly loaded contacts has occured with the realization that the solid components can, in some circumstances, be separated by a continuous fluid film. The hydrodynamic theory of lubrication developed by Reynolds has, for over seventy years, satisfactorily explained the performance of journal and thrust bearings, which possess a high degree of geometrical conformity. The minimum oil film thickness predicted for such bearings is generally many times greater than the height of the surface irregularities of the bearing components. Many contacts in machines do not exhibit the high degree of geometrical conformity enjoyed by thrust and journal bearings, and for these contacts the film thickness predicted by classical hydrodynamic theory is generally much smaller than the height of the surface irregularities. On the basis of this theory a satisfactory fluid film mechanism cannot therefore be predicted for such cases as gears, rolling contact bearings and cams, and yet there is evidence to suggest that this mechanism does operate under some conditions.

A theory developed recently for two dimensional highly loaded contacts[1-5] has shown that full hydrodynamic lubrication is possible in a wide range of rolling conditions. The theory extends the normal hydrodynamic analysis by taking account of the very high pressures which inevitably arise in such contacts. These high pressures produce elastic deformations in the bounding solids which change the geometry of the lubricant film and they also cause a considerable increase in lubricant viscosity. Full solutions to the problem must consider the basic equation governing the elastic distortion of the solids as well as the hydrodynamic equations for the lubricant. Petrusevich[2] produced solutions for a range of speeds in 1951 and until recently these were the only complete solutions for conditions representative of highly loaded rolling contacts. The authors have now completed an analysis of their solutions and it will be shown that a simple formula for minimum lubricant film thickness based on these results is in accord with currently available experimental observations. The theory so far takes no account of thermal effects and the experimental evidence available suggests that this omission is justified in the case of pure rolling. The formula can thus be used with some confidence to predict the minimum film thickness in highly loaded rolling contacts. A comparison between these predictions and the magnitude of surface irregularities should give a good indication of the possibility of establishing a fluid film between the solids in rolling contacts.

Research Report

on theoretical studies made at the Department of Mechanical Engineering, The University, Leeds 2.

Research Team

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Notation

E_1, E_2	Modulii of elasticity of rollers
$\frac{1}{E'}$	$\frac{1}{2}\left[\frac{1-\sigma_1^2}{E_1}+\frac{1-\sigma^2}{E_2}\right]$
G	$\gamma E'$
H	$\frac{h}{R}$
H_m	$\frac{h_m}{R}$
H^*	$\frac{1{\cdot}6\,G^{{\cdot}6}\,U^{{\cdot}7}}{W^{{\cdot}13}}$
h	Film thickness
h_m	Minimum film thickness
R_1, R_2	Radii of rollers
$\frac{1}{R}$	$\frac{1}{R_1}+\frac{1}{R_2}$
U	$\frac{\eta_0 u}{E'R}$
u	Surface velocity of rollers
W	$\frac{w}{E'R}$
w	Load per unit width
γ	Pressure-viscosity index ($\eta = \eta_0 e^{\gamma p}$)
η	Viscosity
η_0	Lubricant viscosity at atmospheric pressure and the bulk temperature of the rollers
σ_1, σ_2	Poisson's ratio

Theory

The form of dry and lubricated contact pressure distributions is shown in Fig. 2. On the inlet side the pressure in the lubricant film builds up as the contact zone is reached and with the exception of one region the pressure throughout the zone approximates to Hertzian. The exception occurs near the outlet side of the contact where the fluid pressure may rise steeply over a narrow band to a value well in excess of Hertzian. This unusual form of pressure distribution is associated with an oil film geometry as shown in Fig. 1 (*b*). Owing to the rapid increase in film thickness beyond the contact, hydrodynamic considerations insist that the termination of the pressure curve should not be far removed from the outlet edge of the Hertzian zone. Since the pressure within the zone must approximate to Hertzian, it is inevitable that the fluid will be subjected to a rapid decrease in pressure as it emerges from the contact. A pressure gradient of this form tends to increase the local rate of mass flow and continuity can only be maintained if the film thickness is decreased near outlet. This leads to the formation of a constriction near the outlet end of the contact zone. Throughout the remainder of the zone the thickness of the lubricant film is essentially constant (see Fig. 1 (*b*)). In order to provide a nearly constant film thickness over most of the contact zone and yet accommodate a local constriction at the end, the basic elasticity equations require a pressure curve of the form shown in Fig. 2. The nature of the pressure curve and its effect on stresses within the contacting bodies is of considerable interest but, in this report, attention is focussed on the oil film thickness; in particular the minimum film thickness h_m, which in general does not occur on the line of centres (see Fig. 1(*b*)).

A dimensional analysis shows that, in the absence of thermal effects, the film thickness is governed by three dimensionless groups:

$$\frac{h}{R} = f\left(\frac{w}{E'R}, \frac{\eta_0 u}{E'R}, \gamma E'\right).$$

These groups will be abbreviated to $H\left(\frac{h}{R}\right)$, $W\left(\frac{w}{E'R}\right)$, $U\left(\frac{\eta_0 u}{E'R}\right)$ and $G\,(\gamma E')$.

An approximate analysis of the conditions in highly loaded contacts was developed by Grubin,[1] and in terms of the above variables his expression for the separation between the cylinders can be written in the form:

$$H = \frac{1{\cdot}95\ (G\,U)^{8/11}}{W^{1/11}}.$$

In his analysis Grubin considered the separation between contacts in the region where the oil film is parallel (see Fig. 1 (*b*)). He acknowledged

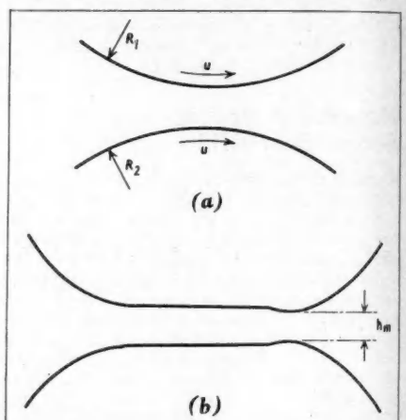


Fig. 1 Roller geometry.

the existence of a constriction near the outlet but did not attempt to allow for this in deriving his formula.

This formula agrees with the authors' results within 20 per cent or so in most cases. However, it has been found possible to fit the theoretical minimum film thicknesses much more closely to a new formula.

The effect of each of the dimensionless groups W, U and G on H has been considered and a formula of the form

$$H^* = k\,W^a\,U^b\,G^c \quad . \quad . \quad (1)$$

has been obtained. When the elastic deformation is appreciable compared with the film thickness, the load parameter W has little influence on H. This result was predicted by Cameron[6] and Blok[7] and it is confirmed by the lower power of W in Grubin's expression. The materials parameter G has a limited range for normal engineering materials and conventional lubricants, and consequently large variations in film thickness cannot be expected from this source. With the large range of speeds encountered in machine contacts it is clear that the speed parameter U will play a predominant role in influencing the film thickness.

From solutions[5] for a wide range of U at typical values of W and G, it was found that the power b in equation (1) was 0·7. An analysis of material effects[4] showed that for a change of G from 2,500 to 5,000, which is the likely range in engi-

TABLE:—*Selection of Experimental Results from Papers by Crook[8] and Sibley et al[9]*

Lubricant	Viscosity at mean disc temperature poise, 10^{-7} lb sec/in²		Pressure/viscosity coefficient, 10^{-8} in²/lb	Load per unit width-lb/in	Disc rolling speed-ft/sec	Minimum film thickness, 10^{-6} in	
						Experimental	Theoretical
White mineral oil	0·091	13·25	6·4	1,299	43·4	16	15
				1,945	29·0	11	10
					43·4	16	16
					72·9	23	23
				4,678	29·0	7	11
					36·5	9	13
					43·4	11	14
Diester	0·097	14·07	6	1,945	29·0	9	12
					43·4	13	17
					72·9	19	24
				4,678	43·4	9	15
					72·9	13	21
Diester	0·062	8·99	5·5	1,945	43·4	9	11
					72·9	12	16
Silicone	0·234	33·9	15	1,945	43·4	51	52
				4,678	29·0	23	35
					43·4	32	46
					86·8	48	76
Crook (R = 0·75 in) Mineral oil	0·37	53·6	17	1,120	6·3	39	22
					10	46	31
					20	57	50
					30	65	66
					38	73	78

neering practice, the power c in equation (1) varied from 0·55 to 0·63 over a wide load range. A mean value of 0·6 can therefore be adopted. The effect of the load parameter[3, 4] was such that the power a in equation (1) should be =0·13. With these powers the constant k was found to be 1·6. The formula representing minimum film thickness thus becomes

$$H^* = 1{\cdot}6\,\frac{G^{\cdot 6}\,U^{\cdot 7}}{W^{\cdot 13}} \quad . \quad . \quad (2)$$

Fig. 3 shows the value of H_m obtained from a range of theoretical solutions plotted against H^*. It can be seen that the formula is in close agreement with the theory over a wide range of conditions.

Experiments

For many years disc machines have been used to study the life of materials in rolling contact, but only recently have reliable measurements been made of the thickness of the lubricant film separating the discs. Outstanding are the contributions of Crook[8] and Sibley[9].

Crook measured the film thickness by a capacitance method and in his experiments he varied load and speed. The overall conclusions of the theory are in agreement with Crook's experimental findings. Quantitatively the comparison is shown in Fig. 4. In calculating H^* for these points the film thicknesses were taken from Crook's Fig. 9. The entry viscosity of the oil was set at 0·37 poise, corresponding to the measurement of disc surface temperature recorded in his Fig. 10. The agreement in magnitude is very satisfactory, although there is a consistent difference in gradient between the theoretical line and Crook's experimental values.

Sibley used an X-ray transmission technique to measure directly the minimum film thickness. He varied load, speed, lubricant viscosity and pressure-viscosity index. The discs were slightly crowned to produce an elliptical contact shape, and Sibley allowed for this in calculating the equivalent load per unit width on parallel faced discs. The calculation of H^* in Fig. 4 is based on Sibley's equivalent loads, and since the effect of load changes on H^* is small it is unlikely that alternative interpretations of the effective load would appreciably affect the results.

The very close agreement between Sibley's experimental results and the predictions of the formula can be seen in Fig. 4. A notable feature of Fig. 4 is the similarity in slope between Sibley's results and the theory. At very small values of the film thickness the experimental results are smaller than the predictions of the formula.

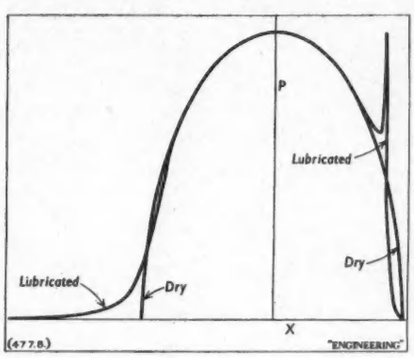


Fig. 2 (above) Pressure distribution in highly loaded dry and lubricated contacts.

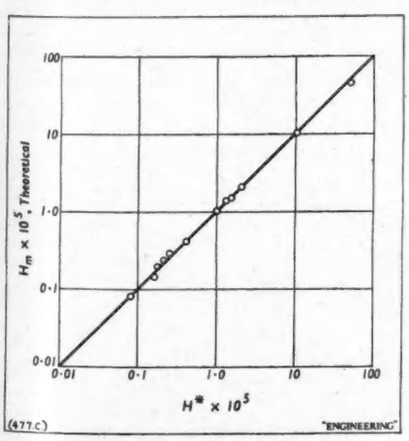


Fig 3 (left) Comparison of H_m—Theoretical with H^*.

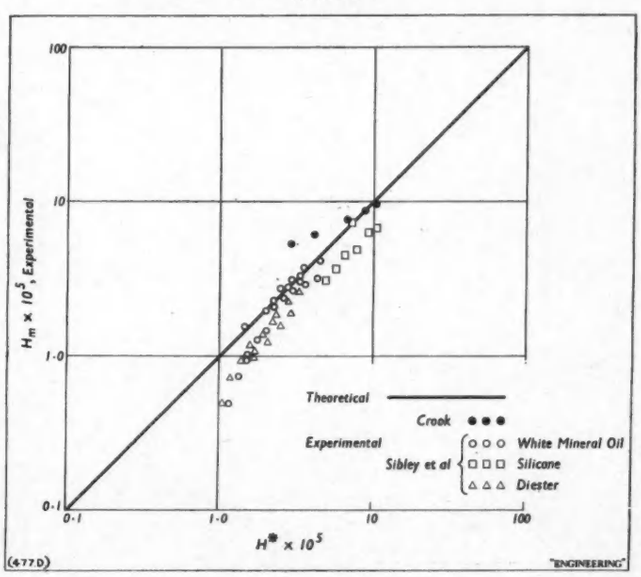


Fig. 4 (right) Comparison of H_m—Experimental with H^*.

It is to be expected that the X-ray transmission technique will underestimate the effective fluid film thickness between surfaces which are not smooth, and this discrepancy will become more significant as the separation is reduced. A value of H_m of 10^{-5} corresponds to a minimum film thickness of about 7 microinches in Sibley's experiments, while the quoted surface roughness of the discs (rms) is 3 microinches. The percentage error between the theoretical and experimental results is appreciable only at values of H less than 10^{-5}.

An attempt to measure the film thickness in running gears was made by MacConochie and Cameron[10] using a voltage-discharge method. The scatter of the experimental results was considerable, but the predictions of the Grubin formula were within the range.

The close agreement between theoretical and experimental results shown in Fig. 4, and the supporting evidence from the MacConochie and Cameron experiment, show that current theory satisfactorily predicts the minimum film thickness in highly loaded rolling contacts. The formula (2) for minimum film thickness can be applied to the rolling contacts encountered in such mechanisms as gears, roller bearings and some cams, and the magnitude of the predicted film thickness in relation to the surface irregularities will indicate the possibility of establishing a fluid film mechanism in such contacts.

References

[1] Grubin, A. N., and Vinogradova, I. E., Book No. 30, Central Scientific Research Institute for Technology and Mechanical Engineering, Moscow, 1949. (English Translation DSIR.)

[2] Petrusevich, A. I., "Fundamental Conclusions from the Contact-Hydrodynamic Theory of Lubrication," p. 209, *Izv. uzbekist. Fil. Akad. Nauk. SSSR*, 1951.

[3] Dowson, D., and Higginson, G. R., p. 6, vol. 1, No. 1, "A Numerical Solution to the Elasto-hydrodynamic Problem," *J. Mech. Eng. Sci.*, 1959.

[4] Dowson, D., and Higginson, G. R., "The Effect of Material Properties on the Lubrication of Elastic Rollers," p. 188, vol. 2, No. 3, *J. Mech. Eng. Sci.*, 1960.

[5] Dowson, D., and Higginson, G. R., "The Lubrication of Elastic Rollers," Xth International Congress of Applied Mechanics, 1960.

[6] Cameron, A., "Hydrodynamic Theory in Gear Lubrication," p. 614, vol. 38, *J. Inst. Petrol*, 1952.

[7] Blok, H., contribution to discussion on ([6]), 1952.

[8] Crook, A. W., "The Lubrication of Rollers," p. 387, vol. 250, *Phil. Trans. Roy. Soc.*, Series A, 1958.

[9] Sibley, L. B., Bell, J. C., Orcutt, F. K., and Allen, C. M., WADD Technical Report 60-189, "A Study of the Influence of Lubricant Properties on the Performance of Aircraft Gas Turbine Engine Rolling-contact Bearings," 1960.

[10] MacConochie, I. O., and Cameron, A., "The Measurement of Oil-film Thickness in Gear Teeth," J. Basic Engng., paper 58-A-142, *Trans. Amer. Soc. Tech. Engrs.*, 1958.

New Heating Units

A RANGE of heat pumps that has recently become available caters for both domestic and office installations. The units are being produced by Lucas Industrial Equipment Limited, Great King Street, Birmingham 19, and will be known as the Climasol range.

There are three models, the Gulfstream, Panama, and Tradewind. The first two are intended for domestic use and the last for office and industrial applications. All three work on the air-to-air circuit using Freon 12 as the transfer medium.

The principle of the circuit is shown in the illustration. Air is drawn in from outside and passes over the evaporator coils to which it gives up heat. The cooled air is then returned to atmosphere by one of the two fans. The Freon 12 is evaporated in the exchanger and passes to a charge modulator and then to the compressor, via a transfer valve. The gas is pumped under pressure to the second heat exchanger where it condenses, giving off heat to the room air which is circulated past the coils by the second fan. Non-return expansion valves in the line back to the evaporator control the direction of flow. Cooling is obtained by reversing the flow of the refrigerant.

The model known as the Gulfstream is intended for domestic use where the householder requires heating only. It does not incorporate the cooling cycle and relies on the operation of the indoor fan to give some degree of summer cooling. It has an output of approximately 32,000 Btu per hour which is sufficient to heat buildings with floor areas up to about 1,200 sq. ft. Larger buildings would necessitate the use of the 3 kW supplementary heaters which have been incorporated in the design primarily for use during periods of extremely low outside temperatures.

Cooling is included in the alternative domestic model, the Panama, which otherwise has the same performance. The fan motors in these units are rated at $\frac{1}{6}$ hp (indoor) and $\frac{1}{8}$ hp (outdoor) and the compressor motor is 3 hp. Air flows are 900 cfm indoors and 1,800 cfm outdoors. The cabinets measure $53\frac{3}{4}$ in high by $34\frac{1}{2}$ in wide by $29\frac{1}{2}$ in deep and weigh 625 lb.

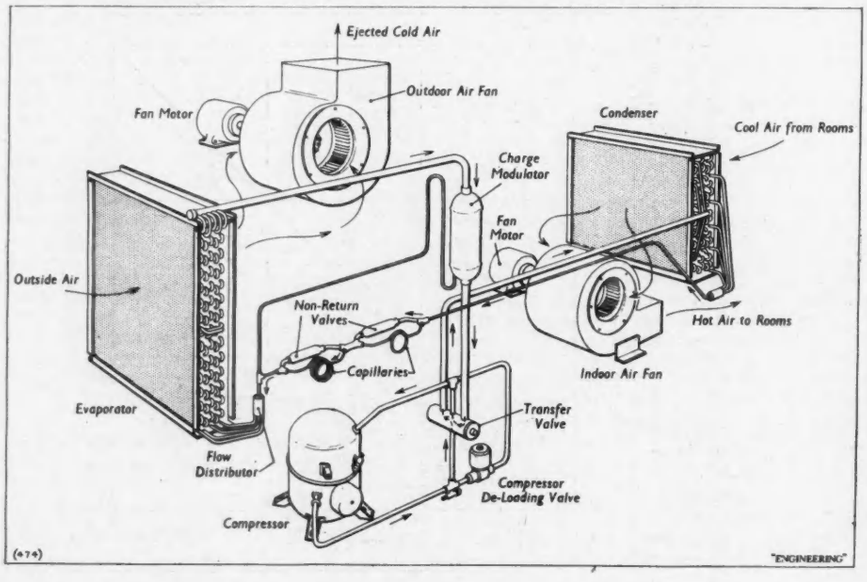
The commercial version, the Tradewind, has a similar performance to the other two but incorporates 6 kW of additional heating (black elements) for use at times of very low outside temperatures, and this amount can be increased if required. The delivery fan power can also be increased to work against a duct resistance of 0·3 in water gauge instead of the 0·15 in for the standard models. It is designed to run from a three phase supply. All three units have automatic defrosting systems and the boost heater is brought into use during the defrost periods so that the heating performance is maintained.

The Climasol units are designed to be used with or without a ducted air system feeding the whole building. A large space such as a showroom can be heated directly without any ducting. A small drain is required to carry away water formed during the defrosting periods. An interesting suggestion is that surplus hot air which normally has to be ventilated to waste may be used as the "outdoor" supply. An example is in a restaurant where the heat generated in the kitchen may be used to warm the dining area, with simultaneous cooling of the kitchen. Another is that beer cellars can be cooled and the extracted heat used to warm the rest of the building. Since an intermediate transfer medium is used there is no risk of the smells being carried from one area to another. In summer the cooling of the evaporator acts as a de-humidifier promoting a greater level of comfort for the occupants.

Newcomers in the field of electric heating are the Valor Company Limited, Erdington, Birmingham. They have just put on the market two models—a convector heater and an oil filled radiator, the latter being available in three sizes. The convector heater is free standing but has wall fixing hooks available for use if desired. It measures 26 in high by 18 in wide and 10 in deep. The rating is 2 kW and a thermostatic control is incorporated so that the heat will be switched off when the room reaches the desired temperature. It will also switch on again when the temperature falls.

The radiators are pressed steel units of slim design. The overall width is $1\frac{3}{8}$ in and the maximum projection from a wall is $2\frac{5}{8}$ in. With a height of 21 in there are three lengths of $31\frac{1}{4}$ in, $46\frac{1}{4}$ in and $61\frac{1}{4}$ in giving heating surfaces of 10, 15 and 20 sq. ft respectively. Three larger sizes are to follow bringing the areas up to 24 sq. ft by keeping the lengths the same and increasing the height. All sizes are available with feet, castors or wall fixings. Thermostatic control is fitted as standard and the electrical ratings of the first three models are 600, 900 and 1,150 watts at 240 V. A built-in safety device is incorporated to provide a safeguard against overheating. The heating element and the fluid are permanently sealed and no "topping up" is required. Top plates are available for all three sizes to prevent discoloration of walls.

One great advantage of the heat pump is that it can be reversed to supply cooling during hot weather.



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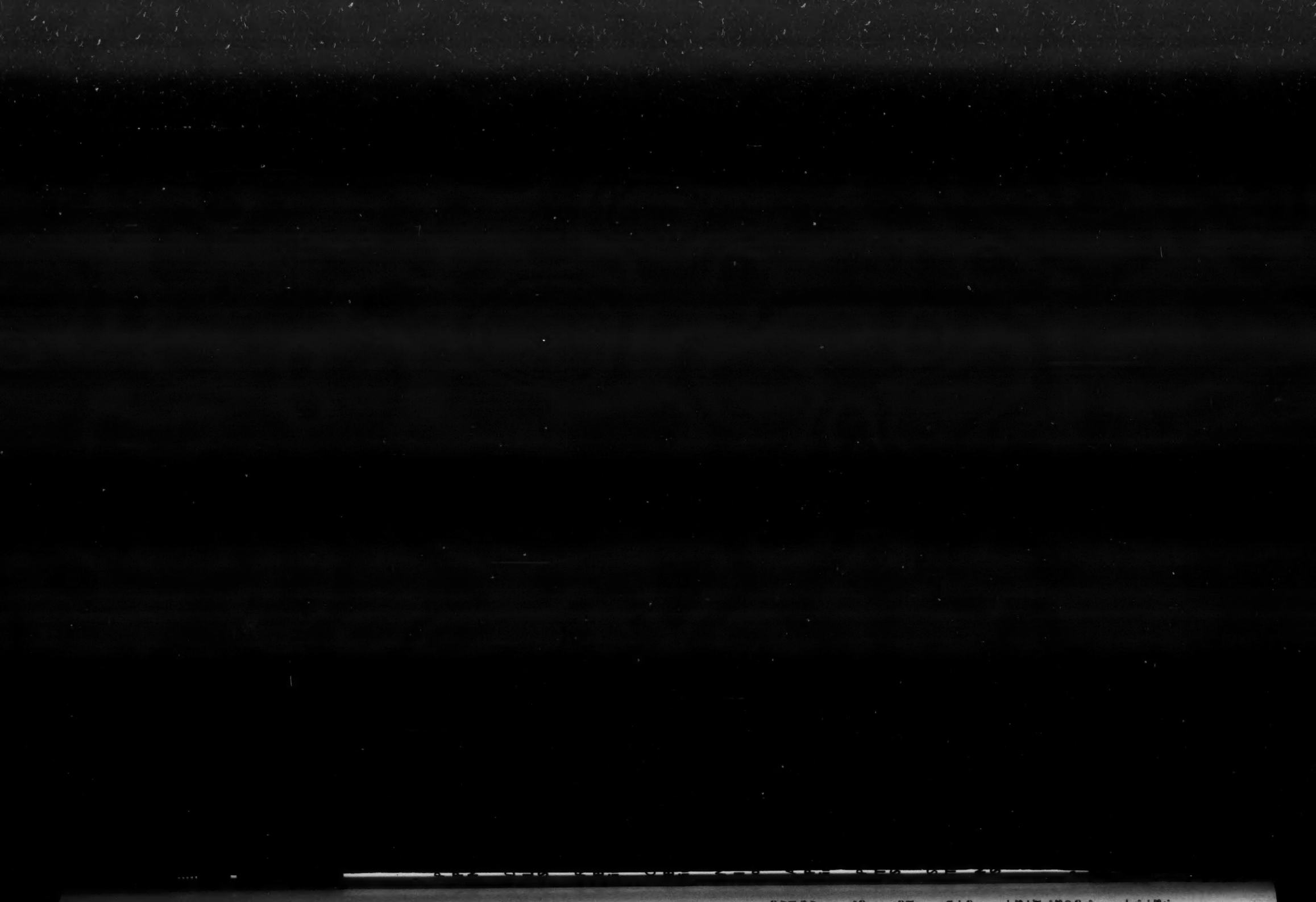
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